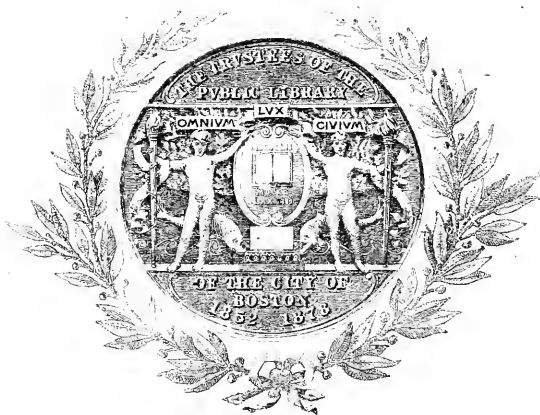


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REPORT
OF THE
COMMISSIONERS

APPOINTED UNDER AN ORDER OF THE CITY COUNCIL, OF

MARCH 16, 1837,

TO DEVISE A PLAN FOR SUPPLYING

THE

CITY OF BOSTON

WITH

PURE WATER.

BOSTON:
JOHN H. EASTBURN, CITY PRINTER,
No. 18 State Street.

1837.

City Council, Nov. 23, 1837.

The Committee on the introduction of Pure Water into the City, who were instructed to request the Commissioners on that subject to report as speedily as might be, have the pleasure now to present the report of those Commissioners to the City Council.

Accompanying the report is a statement by one of the Commissioners of his objections to the plan recommended by the majority.

Respectfully submitted,

SAML. A. ELIOT, *Chairman.*

REPORT.

The Commissioners appointed to examine the sources from which a supply of pure water can be obtained, and the best means of introducing and distributing the same to the inhabitants of the City, respectfully present to the City Council, through the Standing Committee on Water, a detailed Report of their proceedings specifying the plan which they deem it expedient for the City to adopt, with particular estimates of the cost of the same.

It seemed important to us on the outset of our inquiry, to determine the quantity of water required for a full supply for all purposes to which it can be usefully applied.

We found considerable difficulty in forming a satisfactory opinion upon this subject. 1st, on account of the uncertainty of the data for computing the average quantity of water required by each family, the difference in the habits of the people of different cities, not admitting of any general rule for determining the proper measure of supply. 2d, on account of the rapid increase, though at unequal rates, in the population of Boston.

We believe that it is a common opinion amongst householders who are now possessed of wells and cisterns for rain water, that 80 gallons of water a day, for each family, are sufficient for all domestic uses. On turning however to the quantity supplied by waterworks in cities where such works are established, it will be found that a larger quantity than this is used in the dwelling houses. Thus the eight water companies of London, in 1833, supplied 36,790,000 imperial gallons to 196,492 tenants, or 187 gallons to each tenant daily.

In Philadelphia, the average daily supply in 1836, was 3,122,664 beer gallons to 19,678 tenants, or 160 gallons to each tenant, Of these, 13,632 tenants reside in the city, and the remaining

6,046, in the incorporated districts adjoining the city. The above supply in both London and Philadelphia, includes all the water used for watering the streets, extinguishing fires, and all other purposes, those taking the water for manufactories, breweries, baths, and stables, being included under the general name of tenants. Still however, as the greater proportion of the tenants are formed of families, it seems evident that much more than 80 gallons are used by each family.

The population of London in 1831, was 1,521,436, probably in 1833, it was 1,550,000. The supply of water then was $23\frac{1}{4}$ imperial gallons, equal to $27\frac{3}{4}$ wine gallons to an inhabitant. The population of London depends almost exclusively upon the water companies for a supply, and this supply is generally considered as sufficient in amount.

If therefore we take for the supply of Boston, a quantity proportionate to that of London, according to its inhabitants, it would seem that we shall not fall below the requisite quantity. This will give Boston, containing about 80,000 inhabitants, 2,220,000 wine gallons daily, on its present population, provided that the water were at once taken as generally as it is taken in London.

In Philadelphia, the supply in 1836 was, for the city alone, 13,632 tenants, 160 beer gallons, equal to 194 wine gallons each; 2,644,608 wine gallons. The population of the *city* of Philadelphia was in 180,380,462. In 1836, it was probably 93,000. The supply therefore was $28\frac{1}{2}$ wine gallons to each inhabitant. This exceeds in a very small degree, the average quantity furnished in London, and we have adopted it as the basis on which our calculations for the supply of Boston are founded.

The population of this city, now 80,000, has doubled within the last twenty years, and has nearly twice doubled within forty years. Within the last seven years, the increase has been even more rapid than at any preceding period of the same duration. There is no particular reason to anticipate a material check of this increase for a long time to come. It will therefore be expedient to adopt a system of works for a supply of water to the city, which shall be adapted to the prospective demand, which will arise from an increase of population; either by the establishment of works commensurate with such supply, or by adopting a

plan of supply which shall admit of future enlargement. We may fairly anticipate that in five years from the present time, the population requiring a supply of water will be 87,000. This at $28\frac{1}{2}$ gallons each, will require 2,500,000 gallons daily, and at the end of ten years, the population being taken at 105,000, will require 3,000,000 gallons daily.

With these views of the increase of the city, we have thought it necessary to provide, in our designs for works, for an immediate supply of 1,600,000 gallons daily, to be extended in five years, to 2,500,000, and at the end of ten years, to 3,000,000 gallons daily.

Before entering upon an examination of external sources, from which this supply of water may be obtained, it might be expected that we should have instituted an inquiry into the practicability of obtaining it by any form of well within the city. An opinion prevails, it is believed somewhat extensively, that a full supply of water may be obtained from wells, commonly called Artesian Wells, formed by boring to a great depth. Within the last ten years, a large number of these wells have been formed in many places, some of them yielding water of greater purity than the common shallow wells, but in no instance in which an analysis has been made, to our knowledge, equalling the most impure of the pond or river waters, from which it has ever been proposed to supply the city. It does not appear important to us to enter upon the question of the possibility of obtaining 2,000,000 gallons of water daily, from any number of wells of this kind, because if it could be so obtained, even from as small a number as twenty of these wells, the difficulty and cost of raising and distributing it to the inhabitants, must be much greater than that which will be incurred, by bringing purer water from any of the neighboring ponds or rivers, and distributing it by the same means to the citizens. We do not intend by this to give any opinion unfavorable to Artesian Wells, as useful works for obtaining small supplies of water, to be used in the vicinity of the well, especially in districts not much elevated above the level of the sea, while such districts continue unsupplied by an aqueduct or other waterworks. Beyond this, we think they offer nothing worthy the attention of the city government or the inhabitants.

Such being our deliberate conviction of the insufficiency of

any means of obtaining a supply from any source within the city, we proceeded to an examination of the rivers and ponds in the vicinity.

These are as follows :

Names of Ponds and Rivers.	Situated in	Acres in Area.	Feet above high water.	Miles from State House.
Spot,	Stoneham,	283	143,01	8
Reading,	South Reading,	276	about 50	12
Horn and Wedge,	Woburn,	123		10
Mystic,	Medford,	228		7
Spy and Little,	West Cambridge,	140		6
Fresh,	Cambridge,	180		5
Waltham,	Waltham,	52	189,67	11
Sandy,	Lincoln,	152	219,95	15
Morse's,	Needham,	20	109	15
Bullard's,	Do.	35	101,64	15
Long,	Natick,	600	123,52	18
Farm,	Framingham,	193	144,98	21
Shakum,	Do.	89	150,62	22
Farm,	Sherburne,	160		19
Baptist,	Newton,	33	138,99	9
Punkapaug,	Canton,	217	144,77	13
Massapaug,	Sharon,			22
Great Pond,	Weymouth,			20
Charles River,				
Neponset do.				

Of the above, Spy Pond, Waltham Pond, Sandy Pond, Morse's Pond, Bullard's Pond, Farm Pond, in Framingham, Shakum Pond, Farm Pond, in Sherburne, and Baptist Pond, were at once perceived to be singly, insufficient for a supply, while Massapaug Pond is too distant, compared with other sources, to be rendered available. We likewise rejected Reading Pond on account of its distance, combined with want of elevation, and Weymouth Great Pond, on account of its distance and the dark color of its water. Our subsequent examination was therefore confined to Spot Pond, Long Pond, Punkapaug Pond, Mystic Pond, which receives the waters of Horn, Wedge and Winter Ponds, Fresh Pond, Neponset River and Charles River. Of these, the three first, are so elevated that their waters may be brought directly to Boston, through proper artificial channels, without any expenditure for the erection and maintenance of pumps and other machinery, while the four last can only be made to yield a supply to the highest parts of the city, by the applica-

tion of extraneous power, capable of elevating such supply, at least 100 feet. On arranging the sources into these two classes, we were enabled, on comparing those of the second class, one with another, to reject Fresh Pond, as having no superiority over Mystic Pond, except in distance, which is much more than compensated by the supply from Mystic Pond greatly exceeding that of Fresh Pond, it being sufficient for any prospective increase of the city.

Considering it highly important that the purity of any source recommended should be placed beyond a question, we procured analyses of all those not rejected, for reasons heretofore given, except Mystic Pond, from Mr. Hays, of the Chemical works in Roxbury.

The following table exhibits the foreign matters contained in these waters according to this analysis. The 6th, 7th, and 8th columns show the result of the analysis of Dr. Charles T. Jackson, of several of the same waters, and likewise that of Mystic Pond.

Analysis of Waters by Mr. A. A. Hayes, 1837, with those of Dr. Charles T. Jackson, 1834.

No.	Sources.	Quantity in Grains.	Color by Mr. Hayes.	Earthy matter, Mr. Hayes.	Color by Dr. Jackson.	Earthly Matter, Dr. Jackson.		
1.		2.	3	4.	5.	6.		
1	Punkapaug Pond,	100,000	{ Slightly turbid, light yellow tint, faint ear- thy odor, which dis- appears on exposure to the air.	3 gr.	1.20 grs.	{ Clear transparent and colorless. Has a few animalculi.	2.00 gr.	
2	Neponset River,	100,000	{ Color nearly as No. 1. Its odor less dis- tinctly earthy.	5.24	2.47	-	-	
3	Spot Pond,	100,000	{ Nearly colorless. No odor	1.80	1.01	{ Contains a few mi- nute flocculi, but is otherwise transparent and colorless. It con- tains a few oval shap- ed animalculi.	2.40	0.20 gr.
4	Charles River,	100,000	{ Nearly colorless, no perceptible odor. Is more brisk and spark- ling than either of the other specimens.	3.32	1.80	{ Clear, transparent & colorless. No ani- malculi. See note*	4.00	
5	Long Pond,	100,000	{ Resembles No. 4 in Physical properties.	3.033	2.108	{ Has a slight tint of brown, and contains a few flocculi and animalculi.	6.00†	
6	Farm Pond,	100,000	{ Color darker than well water. No odor or taste.	5.36	4.46	{ Clear, transparent & colorless. No floccu- li or animalculi.	3.00	
7	Mystic Pond,	100,000				{ Very slightly tinged with yellow, contains a few animalculi.	2.00	
8	Artesian Well in South Cove, B. & W. R. R. Depot,	100,000	{ Quite turbid when first drawn, from the suspension of a gray- ish white micaceous matter. After stand- ing, it becomes clear and tasteless.	78.20				
9	Artesian Well at City Hotel, South Cove,	100,000				{ White & milky when first brought, from the suspension of partly clay, which subsided in 24 hours, leaving a clear water.	114.33	

*Dr. Jackson says in a second trial, "The water contains a trace of sulphate of lime, but I am not decided whether the oxide of iron exists in the state of carbonate, or in combination with the organic matter. It will require that a very large quantity of water should be operated upon to settle this question."

†Another specimen taken from outlet of Lake, was examined which was free from color, flocculi, and animalculi. Specific gravity same as above, but yields somewhat less vegetable matter.

Although there is some want of agreement between the two analyses, owing probably to the different seasons in which the specimens were taken, they both show that all these waters, except those from the Artesian Wells, are very nearly pure. Chemical analysis, however, is not yet sufficiently perfect to determine several important qualities of the foreign substances found in water. Thus the color and taste which these substances give to water, are in a great degree beyond the reach of analysis as now practised, and can only be determined by the senses, and yet these properties are more important in the character of water than the presence of a little oxygen or inert earthy matter. To form an opinion of the relative clearness and transparency of the different waters, we have compared them repeatedly with each other, and with numerous specimens obtained from distant places, in well arranged lights, and we have found them to stand in the following order, in their freedom from color, the most transparent being placed at the head of the list.

Spot Pond.

Long Pond.

Punkapaug Pond.

Mystic Pond.

Charles River.

Neponset River.

In taste they present no marked differences, all being nearly insipid.

There is apparently no route by which the water of Punkapaug Pond, can be brought directly to Boston, by a structure which shall be less expensive than will be required to bring the supply from Long Pond, while the water of the latter is more abundant in quantity and of better quality in color and taste. We therefore rejected Punkapaug Pond from further examination, considering Long Pond as a more favorable source.

Furthermore, on a comparison of the water of the Neponset with the Charles, as the former river presented no peculiarity in distance, height or chemical purity, commanding a preference to the latter, and as the water of the Charles appeared more clear and colorless than that of the Neponset, we determined that it ought to be preferred, and consequently abandoned all further examination of the Neponset as a source of supply.

It will be seen by the preceding statement that we have thus, by rejecting several of the sources first enumerated from our inquiry, narrowed the necessary examination to the following.

Spot Pond, Long Pond, Mystic Pond, and Charles River, the two first being preferable to all others which we have placed in the class not requiring elevation by artificial means, and the two last as preferable to all others if such means are to be resorted to.

To decide the question of preference between these four sources, requires a more particular description of each. Spot Pond in Stoneham, 8 miles from Boston, contains 283 acres, as appears from a survey made by J. Sargent for Messrs. G. & T. Odiorne, who are the owners of the outlet of the pond. This quantity, however, includes a large tract of low meadow which is covered by water only when the pond is nearly full. The water of this pond is less colored than any water in the vicinity of Boston, except Jamaica Pond, and Baptist Pond, and it is of great chemical purity. The water therefore is unexceptionable. The surface of the water in this pond when level with the wasteway or wier, is 143.01 feet above tide water, while its distance is but 10 7-10 miles on the shortest route by which it would be advisable to lay a pipe. With the exception of a short ridge near the pond all high land may be avoided between Boston and the pond, and an iron pipe laid between these two points without the cost of deep cutting. By this means the water of Spot Pond may be brought to Boston and delivered at the summit of Beacon Hill by a permanent work with the utmost certainty. These advantages over all other waters would have decided us in favor of this pond as a source of supply, were the quantity of water which is collected in it yearly, sufficient, not only for the immediate wants of the citizens, but for such an increase as will certainly be demanded in a few years by the increase of the population.

Various estimates have been made of the quantity of water which may be drawn from this pond yearly, but none of them appear to have been founded upon such well ascertained data as entitle them to confidence. Perceiving at the commencement of our examination the importance of determining this question accurately and definitely, we constructed and placed upon the outlet of the pond an apparatus capable of measuring the discharge

with all the exactness that can be desired. Observations have been made with this apparatus, three times a day from May 4th to October 2d and once a day since that time. These, with observations made upon the height of the pond above the wier or wasteway, from the 31st of March to the 4th of May, from which we have by our subsequent observations estimated the discharge during that time, have enabled us to form an accurate account of the discharge from the 31st of March to the 3d of November. During this time, 217 days, the discharge has been $4 \frac{75}{100}$ cubic feet per second, and the pond has subsided in the same time 56 inches, or its surface on the 3d of November, was 56 inches below the point at which it stood on the 31st of March. We lament exceedingly that the necessity of completing this report prevents us from obtaining, for our guide, in forming an opinion of the discharge of this pond, the observations of a full year. In the absence of this guide however we have endeavored to form an estimate, from the facts already before us, of the amount at which the yearly discharge may be fairly taken. A full account of our observations and mode of estimating the supply of Spot Pond is herewith transmitted in a separate form (marked A). By this it will be seen that we are of opinion that Spot Pond may be relied upon to furnish an average of 2,100,000 gallons a day,—that the discharge may be taken as never falling below 1,600,000 gallons,—and may never be expected to exceed 2,600,000 gallons a day.

With these results we cannot therefore recommend to the City Council to erect works for the supply of the city depending entirely, for the future as well as the present, upon Spot Pond as a source. We shall hereafter show however, that by combining with the pipe from this pond, steam engines and pumps, taking a supply from Mystic Pond, an abundance of water not only for the present but for an extended period in the future may be obtained.

Passing from this for the present, we proceed to an account of our examination of Long Pond.

Long Pond is three or four miles in length, and is about a mile easterly from Sudbury or Concord River, into which its waters are discharged just below the mills at Saxonville. The distance of this Pond from Boston, by the line which we have had sur-

veyed for an aqueduct, is 20 miles 1043 feet. It is 123.52 feet above the level of the sea at full tide. The water of this pond is nearly as colorless as that of Spot Pond, and although the chemical analysis show it to be more impure than Spot Pond, we think its impurity, is not so great as to render it in any considerable degree objectionable.

If this pond be taken as a source of supply, it will be necessary to increase the height of the dam at its outlet, for the purpose of reserving the greater part of the water which would otherwise be discharged during the winter and spring, and by this means securing a supply, to be drawn during the summer and autumn. We have not kept an account of the flow from this pond with the care and accuracy that the account of Spot Pond has been kept, because we have never entertained the same doubt of its sufficiency for a supply. An apparatus was placed upon the outlet however, on the 24th day of July last and observations have since been made daily. Before that time, to the 17th of April, such measures and guages were taken as have enabled us to estimate the discharge from the last named period to the 1st of the present November. A full account of these observations and of the calculations founded upon them is herewith transmitted, (marked B). From these we conclude, that by raising the dam at the outlet of Long Pond and reserving the water collected in it during the winter and spring, a discharge may be obtained from it of $13\frac{1}{3}$ cubic feet per second or 8,743,-680 gallons a day through the year.

Mystic Pond situated in Medford, is 7 miles from Boston by way of Medford turnpike and 9 miles from the same place, by a line over the Mill-dam and through Cambridge, by which a pipe may be laid for conveying its water to a reservoir on Beacon Hill. This pond contains 228 acres, and its surface is nearly on a level with the sea at high water in ordinary tides. The water of this pond is somewhat less transparent and more colored than those of Spot or Long Ponds, while the chemical analysis shows it to contain but a very minute portion of foreign matter, being more pure than Long Pond, and less pure than Spot Pond. It may be taken therefore as of sufficiently good quality for all the purposes of life. As the Mystic receives all the water collected in an extensive basin, comprising within its limits Horn

Pond and several smaller ponds with various brooks and water courses, the quantity of water which flows from it, is not in any degree indicated by the size of the pond. We have examined the outlet at various times during the summer and have found the flow from it constant and abundant when not interrupted by the rise of Mystic River, which at spring tides flows back into the pond. This would require to be cut off by a dam thrown across the outlet of the pond. Were means adopted for saving the water which flows into the Mystic, we have reason to believe that a sufficient supply for the present century may be obtained from it. The only practicable means by which water from this pond can be brought to Boston, is by forcing it through an iron pipe by pumps driven by the steam engine.

The last source to which we proposed calling your attention is Charles River, taken above the lower dam in Watertown. We have found the water of this river more colored than that of Spot Pond, Long Pond, or Mystic Pond. The chemical analysis however shows it to be a very pure water. Notwithstanding this we consider the pretence of coloring matter as a serious, though not an insuperable objection. The opinion has been often expressed that the Charles is rendered very impure by filth from the various mills upon its course. The amount of this is exceedingly minute when diffused through the river, and the same objection may be made, though in a less degree, to all ponds the borders of which are inhabited, or which are frequented by cattle. We are of opinion therefore, that this ought not to be taken as seriously affecting the quality of the water of Charles River. For the quantity of water furnished by this river it may be considered as abundant for the supply of the city, for more than the present century, as it seems to be well ascertained that the flow by the Waltham Mills, is equal to 40 cubic feet a second constantly, in the driest seasons. To obtain a supply from this source, the water, like that of Mystic Pond, must be elevated by pumping. As the flow of this river however, is at all times beyond the quantity required for the present wants of the city, and during a considerable part of the year greatly beyond that quantity, the question arises whether this surplus water may not be used at the falls in Watertown, as a power to elevate the supply required by the inhabitants of the city. An estimate

of the cost for furnishing a supply in this way, using steam only so far as shall be required in the driest season and likewise an estimate of the cost of obtaining a supply by means of steam power alone, will be found with the papers herewith transmitted (marked C).

By this it will be seen that there is no essential difference in the cost of the two methods, and considering the greater extension of the works by the former mode, and the consequent perplexity to the city government in their supervision, we are of opinion that a preference ought to be given to works depending upon steam power alone. Still however, should the City Council determine to obtain a supply from Charles River, this would be a proper subject for a more exact scrutiny.

With this general outline of the sources from which a supply of water may be obtained we proceed to lay before you four distinct plans, with estimates in sufficient detail, of each plan, to enable you to decide which it will be expedient to adopt.

1st, a plan for pumping a supply by Steam power from Charles River to a reservoir to be formed on Corey's Hill in Brookline, 117 feet above tide water, from which it may be brought in an iron pipe to Boston.

2d, a plan for pumping a supply from Mystic Pond by Steam power to a reservoir to be formed on Walnut tree Hill, near the Royall farm in Medford, at an elevation of 126 feet above tide water, from which it may be brought through Cambridge to Boston.

3d, a plan for bringing the water of Spot Pond to the reservoir before named on Walnut tree Hill, and combining with this, a plan for pumping, by steam power, to the same reservoir, from Mystic Pond, such quantity as shall be required to render the supply sufficient by these means whenever Spot Pond shall fail to yield a sufficiency; the whole to be brought in an iron pipe through Cambridge to Boston.

4th, a plan for bringing a full supply from Long Pond by a close covered conduit, formed of stone or brick, and terminating at the before named reservoir to be formed on Corey's Hill, from thence to be brought to the city by an iron pipe.

We wish to observe with regard to these several plans and estimates, that the time devoted to making the examinations of

the route to Long Pond, together with the estimates for this, and for the distribution of the water in Boston, has prevented our giving that attention to the estimates on the three first plans which we could have desired, before presenting them to the city government. We believe, however that they are all sufficiently near the truth, to guide the city government in their choice.

We proceed to describe these several plans in such details as is necessary, to have them well understood, and to give general abstracts of the estimates of the cost of the works required to carry either of the plans into operation.

1st. To obtain a supply of water from Charles River by pumping with steam power, it will be necessary to purchase the dam and water-rights of the lower falls in Watertown, near which place the steam engines and pumps should be erected. From this point the water should be taken from the river into the pumps and forced through an iron pipe of 21 inches diameter, to a reservoir, to be formed on the side of Corey's Hill in Brookline near the Brighton line, at an elevation of 117 feet above tide water, the distance from the falls to the reservoir being 16,910 feet or $3\frac{1}{4}$ miles. The reservoir has been calculated to contain 5,000,000 gallons, being sufficient to supply the city for two days. By the use of this reservoir, the city will be secured in a supply during any unforeseen interruption of the works for two days. The water will likewise be kept running into the city during any short stoppage of an engine, required for oiling or adjusting any part. By this means a pipe of less diameter, and consequently of less cost, will be required than would be necessary were no reservoir used. From the reservoir on Corey's Hill, our estimates provide for an iron pipe of $21\frac{1}{4}$ inches in diameter extending across the Mill-dam to a reservoir proposed to be formed upon the Bowdoin estate on Beacon Hill, the distance being 20,485 feet or 3.88 miles. The calculated discharge from this pipe* at the reservoir on Beacon Hill will be about 4

* In all our calculations concerning the discharges of pipes, we have used the simple formula of Prony, $V = 48.5254 \sqrt{D \frac{H}{L}}$; V, being the velocity of the discharge a second in feet, D, the diameter of the pipe in feet, L, the length of pipe in feet, and H, the height of the source at which the water is taken, above the point of discharge.

cubic feet a second, or at the rate of 2,592,000 gallons a day, and whenever the discharge shall be taken upon the reservoir on Fort Hill, as hereafter described, it will be at the rate of about 8 cubic feet in a second, or 5,184,000 gallons a day, and should the whole water be drawn from the main at the pavement in the market, the discharge, will be about 9 feet a second, or 5,832,000 gallons a day.

The cost of these several works including the purchase of water-rights, and all damages for land, but not including the reservoir on Beacon Hill, are given in a detailed estimate, herewith transmitted (marked D).

By this it will appear that the

Cost of reservoir on Corey's Hill together with land for the same, and land over which the pipe shall pass will be	\$22,954
Damage to water-rights at Charles River, - -	15,000
Pipe from Watertown to Cory's Hill reservoir, -	145,806
Two steam engine and pumps complete, each engine capable of delivering 2,500,000 gallons of water in 20 hours to the reservoir on Corey's Hill—	
\$35,000 each, - - - - -	70,000
Engine and pump houses for both engines, - -	20,000
Main pipe from reservoir on Corey's Hill to reservoir on Beacon Hill 21½ inches diameter, -	189,279
Sundry works not here enumerated, - - -	2,000
	<hr/>
Whole cost of the works, - - - -	\$465,039
	<hr/>

Besides the above there will be required a constant expenditure for keeping the engines in operation. We have had no small difficulty in satisfying ourselves as to the expense of pumping by steam power. A great portion of the cost of pumping water by this means is in the consumption of fuel, commonly coal. We therefore thought it highly important to ascertain, with as much accuracy as possible, the quantity of coal required to be used, in raising a given quantity of water through a given height. As there is not, to our knowledge, a single engine applied to pumping in this country, in which the fuel used produces effects equal to those produced in England, we resorted to the accounts of the performance of the English engines to guide us

in this inquiry. In computing the effect produced by any quantity of coal in pumping water, it is usual to reduce the measures, so as to express the quantity of water, in pounds raised through one foot, by the consumption of one bushel of coal, and this is called the *duty* of the engine.

Since the year 1811 an accurate account has been kept of the performance of the engines used at the mines in Cornwall, and these accounts, specifying the performance of each engine, have been published monthly under the name of *Reports* since 1815. From these it appears that, by a gradual improvement in the construction and management of the engines, the duty was increased, taking the average of the Cornish engines, between the years 1811 and 1835, from 13,500,000 to 50,561,042 pounds. These reports show a very great difference between the performance of different engines. Thus the report for April 1835, giving as above stated, 50,561,042 lbs. as the average duty of 53 engines, shows one performance as high as 91,959,596, and several above 70,000,000, while one is as low as 22,985,113. There have been instances of performances exceeding 100,000,000 pounds raised 1 foot by 1 bushel of coal. The excess in the performance of these engines over those used for pumping water in London, which are of a different construction, and which do not raise upon an average 30,000,000 pounds 1 foot high with 1 bushel of coals, has led many engineers to doubt the accuracy of the reports. No error however has ever to our knowledge, been detected, although constantly subject to a severe scrutiny, and it seems to us, considering the mode in which the measures are taken, the way in which the registers are made, and moreover, that the amount paid for the coals used, is ascertained from the data of the reports, that they are worthy of entire confidence.

In our estimate of the cost of coals for pumping therefore, we have taken these reports as our guide. We have taken a *duty* somewhat above that of the present mean of the Cornish engines, because many of the old engines are not of the best construction. At the same time, we have not supposed we shall be able to equal their highest performances. But as we have found in the reports a small engine, 30 inch cylinder, and said to be "not of modern construction," which during the three months of March, April, and May, 1835, raised 64,148,640 lbs. 1 foot

high, by every bushel of coal consumed, we have thought that we might safely rely on raising 60,000,000 1 foot by the same quantity of fuel.

A particular estimate of the cost of pumping, founded upon the above measure, will be found in the annexed papers, (marked E).

By this it appears that the annual cost for pumping will be \$11,808. This, taking the interest of money at 5 per cent. is equal to a present outlay of \$236,160.

We may therefore take the cost of constructing the works necessary for delivering a full supply of water from Charles River, to a reservoir on Beacon Hill, together with the annual cost of maintaining those works and keeping them in constant operation, as equal to a present outlay of \$701,199 ; add for contingencies 10 per cent. 70,119, makes \$771,318.

To obtain a supply by the second plan proposed, namely, by pumping from Mystic Pond, it will be required to obtain a right to erect a dam near Wear Bridge, to prevent the flowing of the tide water at Spring tides into the pond. Near this place the steam engines and pumps should be erected, which shall draw the requisite quantity of water from the pond and force it through an iron pipe to the reservoir, to be formed on the top of Walnut tree Hill, at an elevation of 126 feet above tide water, and at a distance of 8,250 feet or 1.562 miles from Mystic Pond. This reservoir has been calculated to contain 5,000,000 gallons, or sufficient for two days' supply of the city. From this point, it is proposed to lay an iron pipe of 22 inches diameter, passing through Cambridge, west of the colleges, to Charles River, which may be crossed upon a permanent stone bridge, constructed on the west side of the bridge, leading from Cambridge to Brighton. From this point, it is proposed to pass in the shortest course across the Mill dam to the reservoir on Beacon Hill, specified in the 1st plan, the whole distance being 39,707 feet, or 7.52 miles, the discharge being very nearly equal to that calculated for the last plan at the several points therein given.

The works here enumerated will cost, as appears from a detailed estimate herewith presented (marked F.) as follows :

Dam and Works at the outlet of Mystic Pond, -	\$4,000
Land for reservoir on Walnut tree Hill, and damages to land over which the pipe shall pass to Boston,	5,500
Reservoir on Walnut tree Hill, - - - -	13,000
Pipe laid from the Pond to Walnut tree Hill, -	60,472
Two steam engines and pumps, each capable of de- livering 2,500,000 gallons of water in 20 hours to the reservoir on Walnut tree Hill, - - -	70,000
Buildings for engines and pumps, - - - -	20,000
Pipe from Walnut tree Hill reservoir to Beacon Hill reservoir. - - - - -	358,157
Bridge across Charles River, - - - -	14,000
Sundry works not enumerated, - - - -	9,493
	<hr/>
	\$554,622

The constant expenditure, and wear and tear in keeping the works in operation, may be taken as in the first plan at \$11,808. This, as stated in that plan, is equivalent to a present cost of \$236,160, which added to the above sum of \$554,622, makes the whole cost of works, together with the yearly cost of keeping them in operation, \$790,782; to this add for contingencies 10 per cent. and the amount becomes \$869,860.

In the third plan it is proposed to bring the water of Spot Pond to a reservoir, to be formed on Walnut tree Hill, and in addition thereto, to pump by steam power from Mystic Pond, such quantity as shall be required to render the supply from both these sources, sufficient for the wants of the city.

Spot Pond will yield, according to our opinion heretofore given, an average supply of 2,100,000 gallons daily, never falling below 1,600,000 gallons a day, in the driest season. This supply of 1,600,000 gallons, will be ample for four years, as it would be impracticable to lay the pipes for the distribution of a larger quantity, before the termination of that period. Let us then suppose that at the end of four years the quantity demanded shall be 2,500,000 gallons, enough to supply a population of 87,000 inhabitants, and that after that period, it shall go on increasing for the succeeding six years, until it becomes 3,000,000 gallons, supplying 105,000 inhabitants. The average supply for those six years, will then be 2,750,000 gallons, while the aver-

age supply from Spot Pond will be 2,100,000 gallons. It will require then that 650,000 gallons a day be pumped from Mystic Pond. As the supply from Spot Pond however, may become short, by sudden drought, it will be necessary to provide for such contingency, to erect such works at Mystic Pond, as shall be sufficient for the full supply of the city during any portion of time that Spot Pond may fail, and our estimates fully provide for the cost of works to that extent. In the yearly cost for the maintenance and operation of these works however, it is only necessary to provide for keeping them in constant readiness to operate, with such expenditures for coal and for attendance, and wear and tear as is required to pump, upon an average, 650,000 gallons daily, during the six years, to the reservoir, on Walnut tree Hill. To carry this plan into full operation, we propose to lay an iron pipe, of 22 inches diameter, from Spot Pond, at its southern end, east of the Andover turnpike, to Mystic River, above the upper ship yard; thence crossing that river, upon a permanent stone bridge, it is designed to pass to a reservoir, to be formed upon Walnut tree Hill; identical with that described in the second plan, the distance from Spot Pond being 3.18 miles. From this reservoir, it is proposed that a pipe of 22 inches diameter shall be carried upon the line described in the second plan, across Charles River, by a stone bridge, as described in that plan, and over the Mill Dam to Beacon Hill. The discharge from this pipe will be equal to that produced in the first and second plans. In our estimate of the cost of carrying this plan into operation, we feel very uncertain as to the accuracy of the sum assigned for the cost of land and water-rights. We applied in the early part of the season, to George Odiorne, Esq., joint owner, with Thomas Odiorne, Esq. of the outlet of the pond, and of the right of drawing water from the same, to be informed at what price he would sell his rights to the city. In answer to our inquiry, Mr. Odiorne says,

“To your first and second questions, I reply that my brother Thomas Odiorne, of Malden and myself, are sole owners of said pond, and of the bed of the creek leading from thence to the Mills in Malden, and they have an indisputable right to close the outlet, to draw off, or divert the stream of said pond.

“Your third inquiry being prospective in its tenor, I cannot

so promptly answer. To illustrate my meaning, permit me to reply a little in detail. During the pendency of some years, of the question of a sale of said pond to the city, I have been retarded in the prosecution of my business at Malden, have refrained from extending or improving the works, as far as the power of water would justify.

“ The establishment consists of the following, viz :

A mansion house, barn, and out-buildings, connected, a rolling and slitting mill and machine shop, two new mills, erected the last year, a small factory, for block tin ware, twelve dwellings for laborers, a smith's shop, a coal house, and other small buildings.

“ These all derive their chief value from the continuance of these works, and would turn to but small account, if the business there should cease—which would be the case, if the waters of Spot Pond should be cut off. It would also put an end to my business in the city, in which I have been engaged thirty years, with the expectation of leaving to my son. In estimating the value therefore of Spot Pond, these considerations should not be lost sight of.

“ The value of the pond should also bear some proportion to the daily average quantity of water it yields.

“ That my price however, may form no obstruction in the way of a supply of pure water for the city, I offer to them, through you, one moiety of said pond for sixty five thousand dollars, until the first day of September next, and not exceeding the sum of seventy thousand until the first day of January, 1838.”

We are of opinion that the price above named is much more than the value of the water of Spot Pond, for any manufacturing purposes, including all damages to works already erected. We have therefore added to our estimate of cost of land for reservoir, and damage to land over which our pipe shall pass, such sum as we think equivalent to the value of Spot Pond. Without assuming that this item of the estimate is accurate, we believe that it is sufficiently near the truth, to guide the city council in their choice of the plans proposed. The detailed estimate of the plan here specified, is given in the annexed papers, (marked G.)

From this it appears that the

Cost of iron pipe from Spot Pond to reservoir on					
Walnut tree Hill, will be	-	-	-	-	\$152,436
Dam and apparatus at pond,	-	-	-	-	1,200
Stone Bridge at Medford River,	-	-	-	-	5,000
Reservoir on Walnut tree Hill,	-	-	-	-	13,000
Engine and pumps at Mystic Pond, capable of pump-					
ing 2,500,000 gallons in 20 hours, to reservoir on					
Walnut tree Hill,	-	-	-	-	35,000
Building for Engine,	-	-	-	-	10,000
Pipe from Mystic Pond to reservoir on Walnut tree					
Hill,	-	-	-	-	35,640
Pipe from Walnut tree Hill reservoir to Beacon Hill					
reservoir,					
	-	-	-	-	358,157
Bridge across Charles River,	-	-	-	-	14,000
Land for reservoir on Walnut tree Hill, together with					
damages to land over which the pipe shall pass,					
and our assumed value of Spot Pond,	-	-	-	-	80,000
Several works not enumerated,	-	-	-	-	10,500
					<hr/>
					\$714,933

The constant expenditure for coals, attendance, and wear and tear in pumping 650,000 gallons a day, for six years, equal to 390,000 gallons a day for ten years, whole cost, \$2,890 a year, equal to a capital of \$57,800 at 5 per cent. which added to the above sum of \$714,933, makes the cost of works, with the expense of keeping them in operation, equal to a capital of \$772,33—add 10 per cent. for contingencies, and it becomes \$850,006.

In devising a mode for bringing the water of Long Pond to Boston which forms the fourth plan herein proposed, we perceived at once that its distance, 18 miles, combined with its limited elevation, would place the cost of an iron pipe at too great a sum, to render it expedient to resort to a work of that kind. As that may be considered as the only practicable means of carrying water along an undulating surface, our attention was next directed to finding the straightest line, upon which a work could be built, having a gradual and equal descent from the pond to some point in the immediate neighborhood of Boston. After several examinations, a line was found through the towns of Natick,

Needham, and Newton, where it crosses the Charles River near the Lower Falls. From this point it passes through Brighton terminating at Corey's Hill in Brookline. This line is generally through land easily excavated, requiring no cutting over 36 feet, and except in crossing the Charles River, and a valley near the Agricultural Hall in Brighton, which may be passed by pipes, no high embankments.

It is hardly necessary to state that water may be brought along a course of gentle and equal descent, as here described, without resorting to the expense of an iron conduit. It may be brought in this way by an open canal, or by a covered tunnel, formed either of brick or stone. The open canal is highly objectionable; 1st, on account of its exposure to being used for bathing, and to its becoming a receptacle for foul water and many offensive substances, from persons residing upon its banks, and those passing over the numerous bridges, required at the roads which must cross it. 2d, the large quantity of water that would be lost by percolation through its banks, would diminish essentially the efficiency of the source of supply. These objections appeared to us sufficient to warrant us in withholding our recommendation from this, as a proper structure for supplying the city with pure water. By the close conduit, of brick or stone, the 1st of these objections is entirely removed, and the 2d may be so far reduced that we should entertain no serious apprehension that Long Pond will not furnish a supply, over all waste by leaks, sufficient for the citizens after many years increase.

With these opinions we proceeded to make estimates 1st, for a close conduit of stone, consisting of a floor 9 feet wide and 1 foot thick; upon this two walls are placed $2\frac{1}{2}$ feet high and $1\frac{1}{2}$ feet thick, leaving a clear space of 4 feet wide between them. This space forming the water-course is to be covered by a semi-circular arch $1\frac{1}{2}$ feet thick, the whole being of rough stone without cement, designed to be surrounded with a *puddle* of clay and gravel to prevent leakage.

2d, for a structure of brick laid in hydraulic cement. This structure is designed to be in the form of a cylinder, 8 inches thick, having a clear passage for the water, of 4.6 feet in diameter. Both of these forms present equal areas, and are calculated

to convey upon a slope of 3 inches to the mile, 11 cubic feet of water a second.

It will be perceived from the estimates, that from the greater quantity of excavation required to give room for the stone work, (owing to its shape and greater thickness,) than is required for that of brick, the cost of the entire structure on the former plan, will exceed that of the latter by \$59,192 91. Either of the above works may be considered as imperishable in their materials. We cannot however, speak of them in their other properties with the entire confidence with which we can speak of an iron pipe, because we are not aware that any work precisely similar to either of them, has ever been constructed, and proved experimentally to answer the end designed; while iron pipes have been used through a considerable period of time, and under many varieties of circumstances, and when rightly made, always with success.*

In consideration of the inferior cost of the excavations for the brick structure, and the greater certainty of the water not escaping from it by leakage however, we have taken that as best to be adopted.

In our estimate of the cost of supply from this source, as in that for Spot Pond, we have great doubt as to the accuracy of the sum assumed for the value of water rights and damages. The mill power formed at the outlet of the Pond, is owned by the Framingham Manufacturing Company, no mill now being erected upon it. A second power below this, is used for a carpet mill. The use of the water, after falling into Concord River, is claimed by the Middlesex Canal, and by several establishments at Billerica and Lowell. Probably an equivalent for the use of this water, to the canal and to the lower mill owners, may be found, by forming reservoirs from several small Ponds in the vicinity of Concord River, where the water may be reserved in winter and used as required in the dry season. Not being able, however, in this mass of conflicting interests, to obtain a knowledge of the extent of rights, and the damage which a diversion of the water of Long Pond from its usual channel would occasion, we have added to our estimate for land damages, such sum as we think ought to quiet all the claimants of the waters of Long Pond.†

*See annexed paper (marked H). †See annexed paper (marked I).

By the estimates hereunto annexed (marked J.) it will be seen that the cost of the structure herein proposed, will be,			
For excavation and embankment between Long Pond and Corey's Hill,	-	-	\$183,319
Brick aqueduct, 15 miles 1,600 feet, laid in hydraulic cement,	-	-	453,581
Pipe 30 inches diameter, across Brighton valley and Charles River,	-	-	33,499
Guard gates, bridges and culverts,	-	-	18,468
Water rights, land and land damages,	-	-	110,000
Reservoir on Corey's Hill,	-	-	21,004
Iron Pipe 21½ inches diameter, from Reservoir on Corey's Hill, to Reservoir on Beacon Hill,	-	-	189,279
Sundry works not here enumerated,	-	-	7,481
			<hr/>
			1,016,631
Add for contingencies, 10 per cent.,	-	-	101,663
			<hr/>
			\$1,118,294

In comparing together these several plans, we are to consider 1st, the cost of supply—2d, its sufficiency—3d, the certainty with which it may be relied upon at all times—4th, the purity of the water.

We have seen that the cost to deliver the supply upon Beacon Hill, without distributing it to the inhabitants, will be,

1st plan—Charles River,	-	-	\$771,318
2d plan—Mystic Pond,	-	-	869,860
3d plan—Spot and Mystic Ponds,	-	-	850,006
4th plan—Long Pond;	-	-	1,118,294

As the 2d plan is certainly not superior to the 3d, under whatever aspect it may be compared, and as its execution will require an expenditure greater than that required for the third, we are of opinion that it ought not to be adopted. By adopting the 1st plan in preference to the 3d, a saving in cost of about \$80,000 would be effected. As the constancy of the supply however, in this plan, depends upon the operation of machinery, which always implies some shade of uncertainty, though in this case, as our estimate provides for two complete engines, pumps,

and buildings, either of which will elevate the supply by operating 20 hours per day only, the chance of failure must be very small ; yet taking into consideration the possibility of such a contingency, and likewise the better quality of the waters of Spot and Mystic Ponds, we are of opinion that the 1st plan, founded upon Charles River as a source, ought not to be adopted.

In comparing the two remaining sources with each other, it will be seen that the supply from Long Pond will cost \$268,288 more than that from Spot and Mystic Ponds, the quantity of water brought into the city by the works provided in either plan, for the first ten years, being nearly the same. The works as proposed from Long Pond to Corey's Hill however, will have an important advantage over the works from Spot and Mystic Ponds, in providing for the discharge of a large surplus of water, at the reservoir on Corey's Hill, which may be rendered available at a future day, to meet the wants of the city, by laying a new main from that reservoir to Beacon Hill. Let us attempt to ascertain the value of that surplus water, and the sum that it will have cost to obtain it in the city, when any part of it shall be required, which, as has been heretofore shown, may be taken at the end of ten years. First then, we have the present excess in the cost of the works from Long Pond, over those from Spot and Mystic Ponds \$268,288. This in ten years, with interest, added each year at 5 per cent. will amount to \$436,880. Secondly, the cost of a new main, which it would be expedient to make equal to that now proposed for the same route. The cost of this will be \$189,279, making a total cost of \$626,159.

We have seen that the supply provided from Spot and Mystic Ponds will be ample, and indeed equal to that brought from Long Pond and distributed to the city for ten years. Let us next ascertain whether at the end of that period the works at Mystic Pond can be increased, to meet the increase of demand for water which will then exist without exceeding the above sum of \$626,159, which will have been expended to obtain such increased supply from Long Pond, should that plan be adopted. We have assumed that the population at the end of ten years, requiring a supply of water, will be 105,000, and that it will increase in ten more years, to become 150,000. There will be required then on the average for that ten years, 3,619,000 gal

lons of water a day, or about 1,119,000 a day more than the average quantity provided for during the first ten years. To furnish this quantity, there will be required a new steam engine and pumps, at Mystic Pond, which, with buildings, will cost \$45,000, and a pipe from the Walnut tree Hill reservoir to the reservoir on Beacon Hill, which will cost \$358,157. To this must be added the cost for coals, attendance, and other constant expenses for pumping 1,119,000 gallons daily; which will amount to \$5,285 a year, equal to a present outlay of \$105,700. Thus we see that the whole expense of increasing the supply from Mystic Pond, to meet the wants of the citizens for twenty years, will be \$508,857. Making a difference in favor of the latter plan of \$117,302. If we were to continue a calculation of this kind, for a further period of ten years, we should find that this excess in the cost of works of Long Pond, with accumulated interest, would be fully equal to the sum required to increase the supply from Mystic Pond. We see then, that giving its full prospective value to the surplus water from Long Pond, no advantage can be obtained from it, in point of expenditure, over the plan of supply from Spot and Mystic Ponds.

On the second point proposed for consideration in our comparison, namely, the sufficiency of the supply, the two plans may be considered equal, as the quantity proposed to be brought, is calculated to be sufficient for a full supply of the wants of the citizens, which ever of the plans may be adopted.

The third point of comparison, namely, the certainty with which the supply may be relied upon at all times, we consider of great importance, and we have given it a careful and grave examination. We have no doubt but a conduit may be constructed from Long Pond, to Corey's Hill, which shall be as much beyond the reach of interruption in its operation, as any work of human art can be beyond the reach of accident.

We cannot pretend however that the cost given in our estimate, is sufficient to produce a work of this permanent and perfect character, and we should not think it expedient to increase the expenditure beyond the limits of our estimate, as the object of supply may be obtained upon either of the other plans, with more advantage to the city than by this, if its execution must be at an expense much beyond that which we have assigned to it.

In applying this consideration of the certainty of supply to the plan founded upon Spot and Mystic Ponds ; we can see no reason to fear the possibility of a failure. The plan provides for bringing the water in iron pipes strong enough to sustain three times the pressure of the head to which they will be subjected. Pipes of this kind have been in operation in a great many places; and all experience has shown them worthy of entire confidence. It is true that in carrying this plan into operation, as a steam engine and pumps are required to be kept at work, during a short period, perhaps every year, that part of the supply which is derived from these machines will be subject occasionally, though we think rarely, to interruption. But whenever this shall happen, as the pipes proposed to be laid from Spot Pond to the city, will be sufficiently large to convey, at all times the full supply, they may be safely relied upon through any period of occasional interruption from derangement of the machinery at Mystic Pond, even should it be to the extent of bursting all the steam boilers, or burning down the engine house.

As regards the fourth point of comparison, namely, the purity of the water, the analyses show both Spot and Mystic Ponds, to be more pure than Long Pond. We see no reason to apprehend, however, that the water of Long Pond is not sufficiently pure for all purposes for which it can be required, greatly exceeding in this respect, the waters of the Wandle and Verulam in England, which it has been proposed to substitute for Thames water, in the supply of London. To bring this water to Boston, however, in the structure which we have described, great care must be taken to procure a cement to be used in the masonry, which shall not be liable to be dissolved by the water, as this would impart to it a portion of lime, and other foreign matter, disagreeable to the taste, and highly injurious to its softness. Possibly it will be found, that to answer this condition the English Roman cement must be used. This will add very materially to the cost of the structure. As the estimate now stands then, we are not free from doubt as to the purity of the water which shall be procured through a structure, such as we have proposed, and which we believe to be the best which can be formed without extending the expense to such an amount as shall render the inexpediency of adopting it in preference to any of the other

plans, at once apparent. To resolve this doubt will require information which we have not been able to obtain in season for this report.

We have seen that the waters of Spot and Mystic Ponds are more pure at the respective Ponds than those of Long Pond. Spot Pond is as little exposed to be contaminated with impure substances, wantonly or accidentally introduced into it, as any source which can be resorted to. The waters of Mystic Pond are derived from streams on which are several small manufacturing establishments, and are liable, though in less degree, to the objection alluded to in the notice of the Charles River. For the reason there given, however, we do not consider the objection as of great force. The quality of the waters as they exist in Spot and Mystic Ponds may be preserved beyond all question, in transmitting them to the city in the manner proposed, in the plan of works connected with those ponds; as we believe that no instance can be found in which water has been contaminated in passing through iron pipes.

On a full review of this comparison, a majority of the Commissioners are of opinion that it will be expedient for the city to adopt the third plan herein proposed, namely, that depending upon Spot and Mystic Ponds for a supply.

From whatever source the water may be brought to the city, we recommend the same plan for distributing it to the inhabitants; which is, to form two reservoirs, one upon the summit of Beacon Hill, and one under the summit of Fort Hill, the former at a hundred and four feet, and the latter at fifty feet above tide water. The purpose of these reservoirs is to receive the water from the main, extending to the source or reservoir out of the city, during the latter part of the day and the night, when but little is drawn from the service pipes, and to supply it to the service pipes during the few hours in the morning when the greater part of the water, for domestic purposes is required. By this arrangement, an abundant supply will be kept up at all times in the day, by means of a main pipe, extending from the city reservoirs to the source, of much smaller dimensions than would be required were no reservoirs provided in the city; so that on the whole, a great saving of cost is attained by this expenditure.

From these reservoirs, we propose to lay iron mains in various directions, of from six to twenty inches diameter, through the principal streets to the length of 44,050 feet, or eight and a third miles. By the side of these mains, we propose to lay small iron service pipes, of three inches diameter, from which the water shall be taken by small leaden or wrought iron pipes to the several houses. The object of this double line of pipes, through the above distance, is to avoid the necessity of ever interrupting the flow of the water through the mains, when it shall be required to furnish a supply to a new tenant, which, were it not for the provision here specified, could only be done, by drawing off the water from the main, for several hundred feet, thus interrupting the flow through it, while the operations of boring and inserting the pipe required for the new tenant were performed. In addition to this, we have, to prevent the necessity of breaking up the pavement across the great thoroughfares, for the purpose of laying down tenant's pipes, provided for laying service pipes on both sides of the streets, through the distance of 59,290 feet, or eleven and a quarter miles.

Having thus provided a plan for the conveyance of the water from the reservoirs, in various directions, to different parts of the city, and provided for the distribution of it to the inhabitants of the streets through which the mains pass, we propose to convey it through the remaining streets, and distribute it to the inhabitants, by single pipes of three and four inches diameter, which shall communicate with the principal mains, and with each other, in all directions. According to our estimate, it will require 136,820 feet or nearly twenty six miles of pipe of the kind last specified, to perform this service. The whole length of the streets, thus traversed by mains and service pipes, amounts to 223,477 feet, or forty two and a third miles, being all the streets and lanes, laid down upon Smith's map of Boston, after deducting therefrom five and three quarters miles, for streets laid out upon lands upon which no buildings are yet erected. The whole length of pipe of all diameters proposed to be laid for distribution in the city, is nearly sixty-two miles.

We have futhermore provided in the estimate, for four hundred and forty seven fire plugs, to be placed at proper distances, in communication with the mains and pipes, from which the water

shall be drawn for extinguishing fires. These fire plugs may receive a supply of more than thirty gallons of water a second, from the source without the city, and in addition to this, whatever quantity may be in the reservoir on Beacon Hill. As the water will flow from thence to the height of the source, at least a hundred and four feet above tide water, it may be conducted through hose directly to the top of any common building situated in a low part of the city. It will be seen likewise, that the estimates provide for the cost of a great number of stop cocks, for shutting off the water wherever alterations, additions or repairs shall be required.

A separate estimate has been made for the supply and distribution of the water, to South Boston. This embraces $5\frac{1}{4}$ miles of pipe, and will be sufficient for the wants of the present population of that district.

No provision is made in our estimate, for carrying the water from the service pipes to the dwellings, as we are of opinion that this should be done, according to the practice of other cities, at the expense of the tenants. We have moreover, concluded not to place in the estimate, any sum for forming cisterns and pumps in the streets, for public use, as we are not yet sufficiently informed of the number of these that will be required.

We believe that the plan of distribution herein proposed, will equal that possessed by any modern city. It is simple, certain and permanent, fully sufficient for the present inhabitants, and may be extended with the utmost facility, to meet the future wants of an increased population.

The cost of the distribution as herein proposed, as appears by the detailed estimate, (marked K) will be as follows :

Stone reservoir on the Bowdoin estate, on Beacon Hill, 100 feet square inside, 10 feet deep, to contain 750,000 gallons, including the cost of land,	\$71,539
Reservoir under ground at Fort Hill, 65 feet in diameter, to contain 370,000 gallons, - -	6,224
62 miles of iron pipe of various sizes, laid complete, in the several streets, - - - - -	433,846
733 Stop Cocks, of various sizes, - - - - -	29,583
447 Fire Plugs, - - - - -	8,940
	<hr/>
	\$550,132

Conveying water to, and distributing it in South Boston.

2 $\frac{1}{4}$ miles of 8 inch pipe, for conveying the water to	
South Boston, cost, laid complete, - - -	27,709
3 miles of distributing pipe, cost, laid complete, -	18,936
Stop Cocks, - - - - -	1,000
	<hr/>
	\$47,645
	<hr/>

Making for the complete distribution, including South	
Boston, - - - - -	597,777
Add for contingencies, 10 per cent. - - -	59,777
	<hr/>
	\$657,554
	<hr/>

The entire cost of bringing in the supply on the plan recommended, we have seen was \$850,006. To this add the above sum of \$657,554 for distributing it, and we have the sum of \$1,507,560 as the entire cost for bringing in the water, and distributing it upon the extensive scale herein proposed, including all water-rights, lands and damages, with 10 per cent. for contingencies.

Having thus presented our views of the modes in which an ample supply of pure water may be introduced into the city, for the use of the inhabitants, with estimates of the cost of the necessary works for obtaining such supply—and having specified the method which, in our opinion, it will be expedient for the city to adopt—it may perhaps not be improper for us, to advert to some of the reasons for undertaking a work requiring so large an expenditure. These reasons have perhaps all occurred to the minds of those members of the city government who directed the investigation with which we have been entrusted ; but it may be useful to recapitulate them in connection with the plan of supply proposed for adoption, and the estimate of cost, that a connected view of the whole subject may be presented to the consideration of the inhabitants.

The uses of water are so numerous, and so indispensable to all classes of inhabitants, that it would be a work of some labor, to enumerate all the advantages of an ample and wholesome

supply. Water constitutes so important a part of every one's food, and may, at certain seasons of the year, have so decisive an effect upon the purity of the air which we breathe, that there can be no doubt, that the quality and abundance of the water habitually used in a city, for domestic purposes, and for purifying the streets, yards, and sewers, is a matter which is intimately connected with the preservation of the health of the inhabitants. It is an opinion which has extensively prevailed for many years, that the quality of the water, in the wells of Boston, in general, is not favorable to health. This opinion, although not universally adopted, has the sanction of eminent medical men, deliberately given after long and careful observation and inquiry. Admitting that there were much less weight of authority than there is in fact, in support of this opinion, it is well known, that the water of the purest springs in the city contains a much greater proportion of earthy and saline substances, than that which is now proposed to be introduced—that the wells in many parts of the city afford water containing a still greater mixture of foreign substances—that many of the wells, in consequence of the dense state of the population, are exposed to impurities by the absorption of noxious substances from the surface of the earth—that the rain water, collected in cisterns, is from year to year rendered more liable to impurities, from the increased consumption of coal, and the greater collection of soot upon the roofs—and that consequently the supply of water now relied upon for the general use of the inhabitants, if not positively unfavorable to health, and unfit for use, as many persons repute it to be, is yet far from possessing that degree of purity, which affords the only absolute security, against the deleterious effects which are apprehended from it.

But, aside from the advantages which may be anticipated on the score of health, from an improvement in the quality of the water, in common use for drink, and for culinary purposes, there are others which may be derived from the use of a greater quantity, for washing streets, common sewers, and other receptacles of filth, and thus adding to the general salubrity of the atmosphere, which nothing can so effectually promote in a densely peopled city, as the free use of pure water. Even those therefore who are disposed to give little or no weight to the opinion,

that the quality of the water in common use in the city is unfavorable to health, will be ready to admit, that more or less benefit is to be derived from an abundant supply of water, of undoubted purity and salubrity ; and when it is considered how important a matter is the health of the population of a large city—or even the preservation from epidemic diseases, of a small and most insignificant part of the city, no one would hesitate to purchase such a benefit at a large cost. Even the reputation of being subject to diseases of a painful and dangerous character, from the deleterious properties of the water used by its inhabitants, if founded in erroneous impressions, is a stigma which the guardians of the public welfare should be anxious to remove, although it should be a measure which could be attained only at some cost.

Next to the sustenance of life, and the preservation of health, one of the most important uses of water in a large and populous city, is in checking the ravages of fire. This city has heretofore suffered most severely from the conflagration of vast amounts of property, which in all probability might have been saved, had there been at hand an ample supply of water. It is perhaps not an extravagant opinion, that had the city been provided in the years 1824 and 1825 with the supply of water now proposed to be introduced, an amount of property would have been saved from destruction, in those two years, fully equal to the whole cost of the works now proposed. The deficiency of water then felt has since been partially supplied, by the construction of reservoirs in various parts of the city ; but this supply is very far short of the provision proposed in the plan now submitted, both in the quantity of water, and the facility of access to it. With hydrants, at short distances from each other, in every street, capable of affording at all times, at a moment's warning a copious supply of water, delivered under the pressure of a head more than a hundred feet above the level of the tide, and consequently admitting of being conveyed through hose, without the aid of engines to the top, or to any part, of four fifths of the houses in the city, it cannot be doubted that fires would be more suddenly extinguished, and extensive conflagrations more effectually prevented than they can be at present, under the most active and efficient administration of the fire department. It is the opinion of persons conversant with the hazards and the rates of insurance, that the risk of

loss by fire, and, consequently the rates of insurance, which would be charged by insurance companies, if such a system for the supply of water as is now proposed were introduced, would be reduced about one third,—the present average rate, being not far from forty cents on a hundred dollars, per annum. The amount of property in the city of Boston, exposed to the hazard of destruction by fire, is probably not less than \$75,000,000. Admitting therefore that the risk of insurance on this property is at this time equal to 4-10 of one per cent., and that the proposed supply of water would reduce this risk by one third, the saving which would then be made to the inhabitants of the city in the risk of loss by fire would be equal to \$100,000 per annum. It is not material that this estimate should be scrutinized with great exactness. Whether the sum here named be too high or too low, will not be questioned, that the annual saving from loss by fire would be equivalent to a very large sum, and would go far to reduce the hazard of those distressing conflagrations, which sometimes occur, and which, from the amount of property destroyed, and the number of persons deprived of employment, give a sensible check to the growth and prosperity of the city. If such calamities can be prevented, by providing the most ample supply of water, at a cost not exceeding the rate of insurance which would be necessary to indemnify the loser, it is manifest that the remedy of prevention is more effectual than that of insurance, because it not only insures the owner of property, but prevents the interruption of the labors of industry, and the derangements of business, which often involve numbers in embarrassment and distress.

But it is the ordinary and regular daily uses of water for domestic, economical and manufacturing purposes, which are chiefly relied upon for refunding to the city the expenses to be incurred in procuring an inexhaustible supply, and distributing it to all parts of the city. The quantity proposed to be supplied, and on which the estimate of cost is founded, is 2,000,000 gallons per day at the beginning, increasing annually at such a rate as to make 3,000,000 at the expiration of ten years. This quantity will be equal to the supply of about 72,000 persons, or 12,000 families of six persons each, with $28\frac{1}{2}$ gallons of water to each person

daily, at the beginning, and increasing to 105,000 persons, or 17,500 families daily at the end of ten years.

It will be for the wisdom of the council to determine on what terms and conditions the water shall be supplied to the inhabitants. But, it is presumed that it will be their desire, to furnish it on such moderate and easy terms as will afford an inducement to much the greater part of the inhabitants to take it, and at the same time, at such a rate of annual rent, proportioned as nearly as may be, to the quantity likely to be used by each tenant, as will, at the same time, afford to the city a reasonable indemnity for the cost, and the charge of maintaining the works, and also secure them against the wanton and useless waste of the water; to which it would be liable, if made free to the inhabitants without charge. Such, we learn, has been the system adopted in Philadelphia, and it has been found to operate favorably. Should such a system be pursued, and if we suppose 12,000 tenants to be supplied at an average rent of six dollars to each tenant, it will produce an income of \$72,000. This income, if increased with the growth of the city, in the ratio above supposed, will amount, at the expiration of ten years, to \$105,000. This rate of compensation we name, not so much for the purpose of recommending it to be adopted, as for the purpose of showing what rate will be sufficient, to afford an income equivalent to the annual interest, say 5 per cent. on the estimated cost, together with a sinking fund, for the gradual reduction of the debt. The rent named, while it appears to be sufficient, to indemnify the city for the charge to be incurred, will be a very moderate price to be paid for the accommodation afforded. It will be recollected, that in the proposed mode of supply, the only charge necessary for fixtures, will be for a small pipe, of sufficient length to carry the water to any part of the premises in which it may be required, together with a stop cock. The certainty of a supply at all hours of the day, will render the charge of a cistern unnecessary, and as the water will be of a quality fit for drinking, and for all other purposes, it must in general, supersede the use of wells, pumps, and rain water cisterns. The rent named, instead of imposing an additional charge on the tenant, will, in most cases, be a saving of expense to him, as it will render un-

necessary the charge of building and maintaining in repair, wells, pumps, and cisterns. To many persons, not already provided with wells and cisterns, it will be a great saving of expense, especially to those whose houses are so situated that wells of palatable water are not to be obtained.

In the estimate to be made of the pecuniary worth of such a supply of water, the increased value which it will give to the lots of land belonging to the city, situated on the neck, ought not to be overlooked. The difficulty of obtaining water has heretofore retarded the sale and settlement of these lots. By extending to them the supply now proposed, a new value will be added to this description of city property, as well as to much unoccupied land, belonging to individuals. A further addition may be made to the estimated value of the proposed supply of water, from its uses in several branches of mechanic labor, for the supply of steam engines and other manufacturing purposes.

It should be borne in mind, that in case the system recommended by a majority of the Commissioners shall be adopted, that part of the estimated expenditure which is required to provide for the pumping of a part of the proposed supply of water, from Mystic Pond, may be postponed for a period of three or four years, and so much longer as the waters of Spot Pond shall afford a sufficient quantity, for the use of such part of the inhabitants as shall within that time, make their election to take it. The whole expenditure for distribution also, will not be required, until there shall be a demand from as many as 12,000 tenants, which number will be sufficient to insure the income, before calculated upon.

Considering therefore the grounds which there are for the opinion, that the health of the city will be promoted, by the introduction of a supply of water, purer in quality, and more abundant in quantity, than that now in common use by the inhabitants,—considering the reasons which have been stated for the belief that such a supply of water, as that which is proposed to be introduced into the city, will, in a course of years, be the means of preserving from destruction by fire, a large amount of property, equal perhaps in value, to the whole cost of the works required, for obtaining such supply,—and, considering that, independently of these advantages, the uses of the water for the ordinary do-

mestic and economical purposes of the inhabitants, will be of sufficient value to induce them voluntarily to pay a rent for the use of it, probably sufficient to discharge the interest, if not ultimately the principal of the debt incurred in introducing it, your Commissioners cannot hesitate, strongly to recommend the adoption of one of the plans which they have proposed.

We beg leave to remark, that, although the plans are believed to be practicable, at an expense not exceeding that stated in the estimates, and in a manner to produce the beneficial results described, there is reason to believe that, with further time for examination, improvements may be made in many of the details, without any material variation, certainly without any increase in the cost of execution.

In closing this report, we think it proper to state that we have been indebted to the reports of Messrs. Baldwin and Eddy, for many valuable facts and opinions. We wish moreover, to express our thanks to Peter Vaughan, Esq., of London, for his unremitting exertions in procuring for us information concerning the London water-works, especially from Messrs. Mylne and Wicksteed, the highly respectable engineers of the New River and East London Water Companies. Our acknowledgements are likewise particularly due to Frederick Graff, Esq., superintendent of the Philadelphia Water Works, for the highly important information furnished by him, in the most acceptable manner, concerning the works under his direction.

All of which is respectfully submitted,

DANIEL TREADWELL,	} <i>Commissioners.</i>
JAMES F. BALDWIN,	
NATHAN HALE,	

Boston, November 23, 1837.

*To SAMUEL A. ELIOT, Esq., Mayor and Chairman of the
Committee for procuring Water for the City.*

SIR,

A majority of the Commissioners appointed to procure a supply of pure and soft water for the City of Boston, having in the Report, concluded to recommend for adoption a plan to which I object, I have thought it proper to state to the Committee, in few words, the principal reasons for my non-concurrence in their opinions.

The plan is to obtain a supply of water from Spot and Mystic Ponds. The water of Mystic Pond to be pumped up into a reservoir in Medford, by the power of steam engines to be placed near the pond.

To the plan of pumping up water by steam power in whole or in part for the supply of the city, I object, as it entails forever on the city, the care, trouble and expense of maintaining this power, and of supporting perpetually an establishment for carrying on its operations.

The supervision of the work ; the agents, engineers, overseers and assistants, which such an establishment will require ; the maintenance of work shops, and the stock and tools which must be kept on hand and in order, together with the necessary provision for a certain supply of fuel at the engine station, let it cost a great or small sum, will impose on the city government, such constant watchfulness and care, as to make it a toilsome and perplexing duty, and ought therefore to be avoided.

Another reason for rejecting this mode of raising water, is the necessity the city will always be under, of maintaining the fires, which must never go out, by sea borne coal ; a supply of which may be interrupted or entirely cut off by the acts of our own government, or the interference of foreign powers. And that in seasons of scarcity, in providing for the wants of this establishment, burdens may be imposed on the citizens, by enhancing the price of such fuel as may be necessary for their ordinary consumption.

Probably, it is the difference in the estimated cost of the several plans, which has produced the opinion, given in the report, in favor of the Medford waters. It seems that at the end of the first ten years, provision must be made for an addition supply, for a second term of ten years; say in the eleventh year from this time, the necessary expenditure for the additional supply will have been incurred, and then the difference in the cost, will be only 117,000 dollars in favor of the pumping system.

And what, sir, are ten or eleven years, or what are 111,000 dollars, in a work of this description? Population is increasing and will continue to increase, whether the work goes on now or not—and if we go on in this piece-meal way, we shall ever be at work, and never fully satisfy the wants of the citizens.

72,000 dollars, now put at compound interest, at 5 per cent., will produce in 10 years, an amount equal to the difference in the cost at that time, of the two modes of supplying the city.

If therefore a saving in the estimate of bringing the water of Long Pond, could be made of 72,000 dollars, the two plans at the end of 11 years would cost alike.

If American hydraulic lime will answer the purpose for building the brick aqueduct, and if one cask and a half is sufficient, as some masons believe it is, for laying 1,000 of bricks—then in this item alone, 67,500 dollars can be saved; for $2\frac{1}{2}$ casks of this lime to 1,000 of bricks, have been allowed in the estimate.

The “Duty” of one of the Cornish engines has been taken for the basis of the estimate of the steam power by which the pumps are to be worked. This duty is 60 millions of pounds, raised one foot, with one bushel (84 lbs.) of coal. This duty is not extraordinary in the Cornish mines, where the water is raised perpendicularly, but it is double that which is obtained from any of the engines, used by the eight water companies of London, for pumping water for the use of that city; and it is somewhat singular, that for 20 years this great improvement in pumping has been overlooked, or at least has not been there adopted. I do not mean to say that it cannot be done, but I may say as much as is said in the report about the brick aqueduct, that it has not as yet been successfully tested.

I object to Mystic Pond as a source of supply. The Pond lies below the level of high tides—these tides now flow into and

out of the Pond—and a dam across the outlet must be erected, to shut out the tide waters and retain the fresh.

The effect of building such a dam, will be, in my opinion, to fill up, in some degree, the channel of the river, and produce serious consequences to the inhabitants of Medford ; who would, I think, successfully resist any application, made to the Legislature, for authority to establish it.

The free passage of the water into and from the Pond, gives such a scouring power to the current of the tide in the river below, as to carry off or prevent any deposite of silt or dirt, which, but for this, would remain, and in time, sensibly contract the channel, and reduce the depth of water.

I object to the color and character of the water which composes this source. Much of the water is derived from the Middlesex Canal, from the leaks and wastes on a large portion of its length. This canal is fed from Concord River, in Billerica, a large part of whose waters lie every year, nearly motionless, through the dog days, steeping the grass on the Sudbury meadows, for many miles in extent.

There are also upon the streams which flow into this Pond, 15 or 20 dams and water privileges, where various kinds of mills and factories are in operation ; and although there may not be at present, any, more objectionable than hat factories, tanneries, &c., still, at some future day, they all may contribute, more or less, to render the water unfit for domestic purposes. It is not now the question whether such water is better than the citizens now use, but it is, whether such water is likely to be as pure as can be had from other sources.

I have, sir, thus briefly given the most prominent reasons which have occurred to me, for rejecting the waters of Mystic Pond, and the mode of obtaining it ; and conclude in the language of one of the Directors of the Fair Mount Water Works, “ *if you can get water without pumping it, I advise you to do it.*”

All which is respectfully submitted,

JAMES F. BALDWIN, { *One of the Water
Commissioners.*

Boston, November 23, 1837.

TO MESSRS. D. TREADWELL AND N. HALE,

GENTLEMEN,

Mr. Baldwin, who has been associated with you, in the commission on the introduction of water, has sent me a communication containing some objections to the plan approved by you. As I see no particular reference to these objections in the report, I send you the communication, that you may have an opportunity to present to the city council any remarks you may think it expedient to make.

Respectfully, your ob't serv't,

(Signed)

SAML. A ELIOT.

City Hall, December 1, 1837.

*To SAMUEL A. ELIOT, Mayor of the City of Boston, and
Chairman of the Standing Committee, on supplying the City
with Water.*

SIR,

We have examined the objections of Mr. Baldwin, to our recommendation of a plan of water works, enclosed to us, with your note of the 1st inst., and proceed to make such remarks upon them, as appear to us necessary for the information of the city government.

Mr. Baldwin's first objection is to the plan of pumping water by steam power. The grounds of this objection are, "that it entails forever upon the city, the care, trouble and expense of maintaining this power," and in the next paragraph, he specifies the components of this "care, trouble, and expense," to be agents, engineers, overseers, and assistants; the maintenance of work-shops, and the stock of tools which must be kept on hand and in order, and ends his account with the necessity of keeping a supply of fuel for the use of the engine.

Neglecting, for the present, the last objection, you will no doubt, be surprised to find, as is shown in the estimate, that the whole care and trouble to the city government, or to the superintendent of the water works, for the first ten years, will be in the appointment of one operative engineer, who will employ two common firemen, for about four months in each year. The expense of these workmen to the city, is unquestionably an objection, which amounts, according to our estimate, including all purchases to renew parts of the engine, worn out, to \$2,100 a year. This weight is given to it throughout the report. Indeed, if it were possible to raise water by steam power, without expense, our examination would have ended with Charles River or Mystic Pond. The whole of Mr. Baldwin's objection, therefore, goes to a repetition of one of the items of cost in the plan recommended by us, which, after having been fairly considered and appraised in the report, was found to be of so inconsiderable weight, that the plan of which it made part, was still to be decidedly preferred to any other.

Our answer to the next objection, namely, that founded upon the necessity of providing a supply of fuel, is the same as that given to the preceding, which is, that according to our best judgment, it weighs just \$790 a year, and to this extent it is to be taken against the plan recommended, but no farther. But as this plan, with this objection thus resting upon it, has been shown to be more advantageous than any other, we are unable to perceive why it ought not to be adopted.

There are some amplifications, however, in the recital and repetition of this objection by Mr. Baldwin, which deserve further notice. Thus it is said that the city will always be under the necessity of maintaining the fires, which "must never go out." Now, during the first ten years, it is shown that the engine will be required to raise but 390,000 gallons of water a day, or 142,350,000 gallons a year. The report and estimate, expressly state, that the engine is calculated to raise 2,500,000 gallons in 20 hours, or 1,095,000,000 gallons a year. If therefore, it be kept at work 1,138 hours, or 48 days in any part of the year, the supply will be maintained. It is not true then, that the fires must be always maintained, unless always be taken as equivalent to one seventh part of the time. Again, it is said that

the fires must be maintained by "sea-borne coal, a supply of which may be interrupted, or entirely cut off by the acts of our own government, or the interposition of foreign powers, and that in seasons of scarcity, in providing for the wants of this establishment, burdens may be imposed upon the citizens, by enhancing the price of such fuel as may be necessary for their ordinary consumption."

It is true, that in our statement of the cost of fuel for pumping, we assumed that the engines should be kept in operation by coal, as that article alone is used for the engines which formed the guide in our estimates. Mr. Baldwin well knows, however, that steam may be formed by the heat of a wood fire, as effectually as by that of coal. He has even read of an engine in Cornwall, pumping water by a fire of turf, at an expense of eight pence half penny a day. As to the hardship the citizens are likely to experience, from an advance of the price of coal occasioned by the extent of our demand in the market, we beg leave to refer you to the coal merchants to decide how much the price is affected, by an extra demand of 1 or 200 chaldrons a year.

After this statement of objections, Mr. Baldwin proceeds ; "Probably it is the difference in the estimated cost of the several plans which has produced the opinion given in the report, in favor of the Medford waters."

Let us see how far this statement is borne out by the report. On turning to that, you will find that the several plans are compared one with another as follows, 1st, their relative cost ; 2d, the quantity of water to be obtained by each ; 3d, the constant and unfailing certainty of their operations ; 4th, the purity of such water. Under this comparison, the plan recommended was adjudged to be superior to that founded upon Long Pond, in all but the second point, in which they were shown to be equal. How can it be said then, that our decision was made upon the relative cost alone, when it was shown that, in our opinion, an equal quantity of better water could be obtained with greater certainty by the plan recommended, than by that rejected ? The difference in cost, being \$268,288, in our opinion, deserved, and it received our attention, and had its due influence upon us, though by no means paramount, or indeed equal to that produced by our greater confidence that the supply, by the plan recom-

mended, will not be subject to interruption by any event which seems to us in the least degree likely to happen.

Mr. Baldwin next says, "It seems that at the end of the first ten years, provision must be made for an additional supply for a second term of ten years," and again, "If we go on in this piece-meal way, we shall ever be at work, and never fully satisfy the wants of the citizens." In our opinion, they must be very unreasonable not to be satisfied with a barrel of water a day, each, man, woman and child, and this provided for them at the cheapest rate possible. We think they ought to be better satisfied with this, than to pay a greater price for a larger quantity, which they do not want, and which will be at their disposal only at the reservoir on Corey's Hill. It would no doubt be inferred from the manner in which Mr. Baldwin makes this statement, that if the plan depending upon Long Pond were adopted, no future "piece-meal" addition would be required to it. It will be seen by the report and estimates, however, that the pipe from the reservoir on Corey's Hill, where the brick conduit from Long Pond is laid out to terminate, will bring no more water to Boston, than will be brought by the pipe from Spot and Mystic Ponds, and that were that plan adopted, at the end of ten years, or whenever the city shall require more than 3,000,000 gallons a day, an additional pipe, 3.88 miles long and costing \$189,279 must be provided. But let us look a little farther into the future. When the population shall have increased to 240,000, which may be in 30 or 40 years, all the water which will be supplied by the conduit from Long Pond to Corey's Hill, or all the water of Long Pond, will be required for their use, and an additional population can only be supplied by new works, perhaps by pumping from Mystic Pond. It appears, therefore, that additions will be required, to the works, whichever plan may be adopted, but as Mystic Pond will furnish much greater quantity of water than Long Pond, it will supply the increased works through a much longer period.

After an effort to show that, giving their full prospective value to works connected with Long Pond, they will not, at the end of ten years, exceed in cost, the plan recommended in a greater sum than \$117,000 as stated in the report, and that that sum may be produced at the end of ten years by a present investment of

\$72,000 continued at compound interest, a fact which we shall not gainsay, Mr. Baldwin proceeds, "If American hydraulic lime will answer the purpose for building the brick aqueduct, and if one cask and a half is sufficient, as some masons believe it is, for laying 1,000 of bricks, then in this item alone, 67,500 dollars can be saved, for $2\frac{1}{2}$ casks of this lime to 1,000 of bricks, have been allowed in the estimate." Of these two hypotheses, the first, implying the use of American hydraulic lime, was admitted perhaps with too great liberality or favor to the plan of bringing the supply from Long Pond, in the estimate given in the report. The second, implying that the estimate provides for a much greater quantity of cement than will be required, is in direct contradiction to the best evidence obtained from practical men in the course of our examination of the work proposed. Mr. Baldwin knows that one very intelligent and experienced mason declared, repeatedly, that three casks of hydraulic lime will be required to lay 1,000 bricks in the form proposed. Would it not be most unwarrantable then, to assume that less than the estimated quantity will be sufficient? Would it not be much more reasonable to reverse the conditions, and say "If English Roman cement be necessary to ensure the purity of the water, and if three casks of this cement are required to lay 1,000 bricks, the estimate will fall short of the expenditure in the sum of \$236,250. Indeed we are not without some slight apprehensions, as stated in the report, that American hydraulic lime will be slowly dissolved and make the water both hard and bitter. A very strong case of this kind has occurred at Lowell, and the appearance of that admirable work, the dry dock in Charlestown, is not calculated to allay our apprehensions.

On a review of the description and estimates of the aqueduct, as proposed from Long Pond, we can find no reason to hope that any considerable saving in the expenditure can be effected. No unnecessary materials or structure, seem to have been provided for. The work as laid out by us will not compare in solidity or strength with that now constructing for the supply of New York. We have moreover relied upon a single conduit, never to be interrupted by repairs for a period exceeding two days, although the late eminent Sir Thomas Telford in his project for supplying water to London from a new source, thought in neces-

sary to provide for laying two such conduits, both built in a more thorough manner than that proposed by us, and each independent of and separated from the other, not choosing to rely solely upon a single work of this kind. We do not mean by this to say that the work, as proposed in the report will be insufficient for the object, but that, no unnecessary expenditure is contemplated in the estimate, and that no saving in cost can be expected upon it.

The two succeeding paragraphs of Mr. Baldwin's paper, tend to cast doubt upon the conclusion arrived at in the report, upon authorities there stated, that 60,000,000 lbs. may be raised 1 foot high by the steam engine, with a consumption of one bushel of coals. The foundation of this doubt is somewhat singular. He believes that this *duty* is reached, (it is often exceeded by more than fifty per cent.) in Cornwall, but still retains his doubts whether we here, can equal it, for the reason that the London Engineers have not yet attained to it. The London Engines, as is known to Mr. Baldwin, on the authority of Mr. Wicksteed, engineer of a London water company, are very differently constructed and wrought, from those of Cornwall, and it seems to us that the reasonableness of our conclusion, that we can approach somewhat near, at least, to the common result produced in Cornwall, by using the same instrument which is there used, cannot be successfully impugned, by showing that other persons cannot produce a like result with a different instrument. In the progress of the arts, one community or city must necessarily be in advance of another. It is but a few years, not, "twenty," since the Cornish engines attained their present excellence, an excellence which the London companies are now about to imitate; as Mr. Weeksteed, the engineer mentioned in the preceding paragraph, in a communication now in our possession, and which has, we believe, been read by Mr. Baldwin, says "we are about to erect a Cornish engine at Oldford," the site of the East London water works, "which will consume not more than one third of the coals we now use."

The next paragraph of Mr. Baldwin's paper is as follows. "I object to Mystic Pond as a source of supply. This Pond lies below the level of high tides, these tides now flow into and out of the Pond, and a dam across the outlet must be erected, to shut out the tide waters and retain the fresh.

“The effect of building such a dam, will be, in my opinion, to fill up, in some degree, the channel of the river, and produce serious consequences to the inhabitants of Medford, who would, I think, successfully resist any application made to the Legislature for authority to establish it.

“The free passage of the water into and from the Pond, gives such a scouring power to the current of the tide in the river below, as to carry off or prevent any deposit of mud or silt, which, but for this, would remain, and in time, sensibly contract the channel and reduce the depth of water.”

We look in vain through the foregoing statement, for any thing which affects the quality of the water of Mystic Pond, or the security, cost, or abundance of supply. We cannot however but lament that it should have been thus made, because it is possible that it may raise groundless apprehensions in the minds of the citizens of Medford, and we shall therefore give it more attention than we should otherwise have thought it necessary to bestow upon it. It is true as stated at length in the report, that immediately before the high water of spring tides during the dry season, a current passes from Mystic River into the Pond, and the quantity of water which passes up Mystic River from the sea, is by this means in a very small degree, increased. But whether the channel of the river below the Pond, is thereby cleared or scoured, we think admits of great doubt. We are unable to perceive why as much mud and silt should not be brought up the river from the extensive flats north of Charlestown, as will be carried down by the reflux of the same water. In our view the difference either way must be altogether inappreciable; and we think this view is warranted by the custom almost universal, of damming the tide waters upon our sea-board. The rivers and large creeks of this Commonwealth, for example, are with very few exceptions crossed by dams near their mouths, which effectually bar the flow of the tide waters.

The Charles is thus dammed at Watertown, and a flow of water to the depth of three feet at spring tides, cut off. The Neponset is crossed by two dams at Milton Bridge, which stop the influx of the neap tides, even. The rivers at Salem, Beverly, and Ipswich are all crossed by dams cutting off the flow of tide water. Can it be that this practice has been persevered in

from the earliest times, without complaint from those interested in navigation, if any injury was produced upon the channels and harbors ? With all this before them, we believe that the citizens of Medford will regard all consequences which can be produced by a dam across the outlet of their Pond, as too trivial to excite uneasiness. As for any "successful resistance to an application to the Legislature for authority to establish it" which Mr. Baldwin thinks will be made by the citizens of Medford ; we beg to refer you to the 116th Chapter of the Revised Statutes. You will there find, "That any person may erect and maintain a water mill, and a dam to raise water for working it, upon and across any stream that is not navigable, upon the terms and conditions, and subject to the regulations herein after expressed." These terms and conditions are essentially, that the person building the dam shall not place it upon another man's land without consent from the owner. That it shall not produce injury to another mill upon the same stream, and that the owner shall be liable in damages for all land flowed by it. More than this, the Legislature specially granted in the year 1836 to the Boston Hydraulic Company, incorporated for supplying the City of Boston with water, the right to take any Ponds or lands covered with water north of Charles River, and within 12 miles of the City of Boston, and "The said corporation may erect dams at the outlets of any Ponds which said corporation may take pursuant to the provisions of this act." This company has never taken possession of these rights, and surely the Legislature will not now deny, to the City of Boston, the same privileges which were then granted to a private company.

Mr. Baldwin's last objection is made to the "color and character" of the water of Mystic Pond. He grounds this objection upon the facts that a portion of the water is remotely derived from Concord River through the Middlesex Canal, and that there are several mills upon the other water courses which empty into the pond. For that portion of the supply which comes from the Canal, as it is for the most part *filtered* in its passage from the Canal to the pond, we lament that it is not more abundant. With regard to the influence of mills in rendering waters impure, we have already expressed our opinion in the report, when giving an account of the water of Charles River. It is by no means

pleasant to dwell upon the sources of impurity to which all waters, which can be procured in civilized life, are exposed, whether in ponds, rivers, wells, or even springs. The mills mostly saw and grist mills, upon the streams connected with Mystic Pond are we believe, very harmless things. There is no evidence of contamination produced by them, either in the appearance of the water or in its analysis. We need not repeat that the analysis shows the water to be more pure than that of Long Pond, which receives in the dry season the drainage from an extensive swamp or meadow. While therefore we believe that the water of Mystic Pond ought not to be rejected for want of purity, we may remind you that Spot Pond, from which in the plan recommended, the greater part of the water will for many years be derived, is the most pure and unexceptionable of all the sources examined by us.

Having thus examined, we believe all the objections of Mr. Baldwin, and made such remarks upon them as seemed to us necessary, we leave the subject to those who alone have authority to decide upon the whole question.

Very respectfully, your obedient servants,

DANIEL TREADWELL,
NATHAN HALE.

Boston, Dec. 8, 1837.

PAPER MARKED A.

Quantity of Water of Spot Pond.

With the consent of the proprietors of the pond, an apparatus was placed at the outlet, for measuring, at pleasure, the quantity of water flowing from it, during a given number of seconds ; and an agent was employed to make such measurement three times a day, from May 4th, to October 2d. Since the last named date, the measurement has been made but once a day.

The water, after flowing from the pond, through the gate or over the wasteway, is received into a smaller pond or reservoir, at some distance below the gate, and from this reservoir it is discharged over a fall of considerable height, before coming to the mills of Messrs. Odiorne and the other works. At this fall a trough is placed, into which the water is received through a notch, 36 inches in width, with an even horizontal bottom ; and a guage or scale on which the inches and parts are accurately marked, is placed in the reservoir, in such manner as to indicate at all times, the height of the surface of the water, above the bottom of the notch.

The trough is placed at such a slope that the water flows rapidly through it, and is discharged into the brook below. Beneath this trough, a cubical box or cistern is so placed, that the whole current of water may be discharged into it, by a sudden removal of a section of the trough. By replacing the section of the trough, the current is again suddenly discharged into the brook below. The cavity of this box measures six feet on each side, and consequently it contains 216 cubic feet. A scale is fixed on the inside of it, by which the depth of water in it, at any time, may be readily observed, and the quantity accurately determined. It is also provided with a gate, for the discharge of the water at pleasure.

All the water, therefore, which is discharged from Spot Pond, either over the wasteway, or through the gate, flows regularly through this trough, and may be at any time discharged for any number of seconds into the box ; the time being noted by the observer, by means of a minute or half minute glass. The height to which the water rises on the scale, shows the quantity of water discharged during the time.

The agent has recorded, not only the quantity of water thus drawn off at each observation, but also the height of water in the reservoir at the time, above the bottom of the notch, from

which the quantity of the flow may be computed by a well known rule.

Our observations upon Spot Pond commenced March 31st, 1837, when the Pond was nearly full, about 2 inches below the top of the wasteway. There was drawn from it from March 31st to November 3d, 217 days, upon an average, 4.75 cubic feet a second, and this draft lowered the water, 4 feet 8 inches. The whole quantity of water as measured which ran out during this time was 89,056,800 cubic feet, which is equal to 1,829,932 gallons a day for 365 days or one year.

Taking the area of the Pond when at its mean height at 240 acres=10,454,400 feet, this quantity, 89,056,800 cubic feet, would have filled it 8.51 feet high. It was drawn down 4.66 feet, and this basin, 240 acres large and 4.66 feet deep, contained 48,717,504 cubic feet. Hence of the whole quantity 89,056,800 cubic feet drawn, 48,717,504 cubic feet were given by lowering the Pond, and the remainder 40,339,269 cubic feet were supplied by rains and springs ; and in addition to this a quantity equal to the whole evaporation, which was not measured.

The question now comes, will the Pond, if the gate should be shut down, and no further draft made from it, fill from rains and springs, before the 31st of March, 1838, to the point at which it stood on the same day this year ? that is 4 feet 8 inches above its present level ? For if it will so fill, then the *yield* of the Pond for the year may be taken at 1,829,932 gallons a day for the whole period.

By the observations made in April and May last, we found that the Pond received during those two months an accession of 37,807,755 cubic feet which is only 30 per cent. less than the whole quantity, 48,717,504 cubic feet, required to fill the Pond. The quantity of rain which fell in April and May, according to the observations of Dr. Hale in Boston was 8.82 inches ; according to Dr. Hobbs at Waltham 10.96 inches,—mean 9.89 inches which is considerably above the rain of the same months in ordinary years. But as the snow had nearly all disappeared on the 1st of April, it is difficult to conceive of the Pond having received an accession of more than two-thirds as much water during April and May, two months, as it ordinarily receives in November, December, January, February and March, five months. This hypothesis is strengthened by the observations made for several years at Jamaica Pond, as published in the report by L. Baldwin, Esq., which show the increase of that Pond upon an average of ten years, to be about three times as much in February and March, as it is in April and May.

If then we conclude that the accession of water to the Pond in the months of November, December, January, February and March, five months, be 50 per cent. more than the accession

during the last April and May, two months, we shall have $37,807,745 + 18,903,877 = 56,711,632$ cubic feet, or 7,994,128 cubic feet more than enough to fill the Pond. We have seen that if the pond be filled only, under the conditions before stated, the yield for the year will be 1,829,932 gallons a day. As the year has been unusually dry, we feel warranted in taking the average produce to be 2,100,000 gallons, the minimum 1,600,000, and the maximum 2,600,000.

PAPER MARKED B.

Quantity of Water of Long Pond.

The discharge from Long Pond, as near as we could measure it, on the 17th of April, when we first examined its outlet, was 22.90 cubic feet a second. Again, on the 1st of June, the discharge, by our estimate, was 43.33 cubic feet. This great discharge, was produced by the removal of a plank forming a part of the stopwater, sometime between the 17th of April and the 1st of June, and by it the water of the whole pond was drawn off to the depth of 11 inches. We have no means of ascertaining the day on which the stopwater was removed, but as the flow on the 1st of June was 20.43 feet per second greater than on the 17th of April, and as the pond in the mean time was drawn down 11 inches, it seems reasonable to attribute the increased flow on the 1st of June, to the removal of the plank, and to assume that if the pond had not been drawn down, the average flow would not have varied materially from what it was computed to be on the 17th of April, viz. 22.90. We may assume, moreover, that the accession of water to the pond, during the months of February and March is equal to that of April and May. We have then, for these four months, 120 days, an accession to the pond, of 22.90 cubic feet a second, 237,427,000 cubic feet.

By our observations, made from the 27th of July to the 30th of September, 66 days, the discharge from the pond was 39,337,920 cubic feet, and the surface of the pond subsided 8 inches under this draft. This 8 inches, or 26,136,000 square feet, the area of the pond, gives 17,424,000 cubic feet. Hence, of the whole quantity, 39,337,920 cubic feet drawn, 17,424,000 cubic feet were taken from the stock of the pond and the remainder, 21,913,920 cubic feet, were derived from rains and springs flowing into the pond during the time of the draft. This 21,913,920 cubic feet in 66 days, is equal to 3.85 cubic feet a sec-

ond, and we may take the yield of the pond during the months of July, August, September and October to be 3.85 cubic feet a second, or for the 122 days, 40,582,080 cubic feet. Then if we add to this the quantity, 237,427,000 cubic feet, which it has been before shown may be collected in the pond, during the months of February, March, April, and May, we have 278,000-980 cubic feet, furnished to the pond in eight months, viz. February, March, April May, July, August, September, and October. This is equal to $13\frac{1}{2}$ cubic feet a second, nearly, for the 242 days comprised in these eight months. It must therefore be apparent, that if we draw from the pond but $13\frac{1}{2}$ feet a second, during February, March, April, and May, a surplus may be retained sufficient to provide for an equal draft through July, August, September, and October. During the remaining months of the year, namely, June, November, December and January, we have good reason to believe that the pond will receive $13\frac{1}{2}$ cubic feet a second from rains and springs, consequently a draft from it to that extent, will neither increase nor diminish its stock. We have in this way $13\frac{1}{2}$ cubic feet a second provided during the year.

To reserve in the pond the quantity 99,926,784 cubic feet, required to be drawn off during July, August, September and October, it will be necessary to raise the dam at its outlet, so that the pond be flowed 3.82 feet above its lowest point, or about 18 inches above the right of flowage, possessed by the present owners of the outlet. Although the flow from the pond may be made equal to $13\frac{1}{2}$ cubic feet a second, or 8,640,000 gallons a day, as herein shown, we do not rely, after making an allowance for waste by leakage, on obtaining more than 11 feet a second, at the reservoir on Corey's Hill, and our aqueduct is calculated to deliver this quantity, which is equivalent to 7,128,000 gallons a day.

PAPER MARKED C.

In pumping to a height of 117 feet, at a distance of $3\frac{1}{4}$ miles, in addition to the force required to raise the water, we must provide for an additional force in overcoming the friction of the horizontal pipe. The amount of this force depends upon the size of the pipe. We assume it in this case, as equal to a column of water 33 feet high, and it will be hereafter seen that this will be near the quantity required in practice.

The fall at Bemis' Mills is 5 feet nearly, and at May's Mills 6 feet when the tide is out, making about 11 feet fall. To pump 2,500,000 gallons = 333,333 cubic feet a day = 3.86 feet a second 150 feet high, will require $\frac{150}{11} = 13.6$ feet $\times 3.86 = 52.5$ feet to produce an equilibrium between the wheels and pumps. Add 50 per cent. for loss in giving motion, and we have 78.75 feet a second.

It will require then $78\frac{3}{4}$ feet of water a second, at a fall of 11 feet, during the 24 hours, to produce the necessary power to pump 3.86 feet 150 feet high.

The flow of water at the Waltham Mills, is estimated by Dr. Hobbs, for the four driest months, July, August, September, and October, at from 40 to 60 cubic feet a second.

We cannot therefore rely upon more than half the quantity required during four months of the driest season, and if we assume that during the remainder of the year, there will be water enough for pumping the whole supply, we may estimate the cost of erecting works, and pumping, as follows:

Cost of pumping by water and steam.

Water Rights, - - - - -	\$70,000 00
Canal to unite the two falls with guard gates, &c. -	30,000 00
Four water wheels and pumps, \$8,000 each, -	32,000 00
Buildings, - - - - -	20,000 00
Steam Engine and pumps, capable of pumping 2,500,000 gallons in 20 hours - - -	35,000 00
Building, - - - - -	10,000 00
	<hr/>
	\$197,000 00

Yearly expense for water works,

Superintendent, - - -	\$1,000 00
3 men at \$500 each, - - -	1,500 00
Wear and tear, - - - -	1,500 00
	<hr/>
	\$4,000 00

Steam works to pump 1,250,000 gallons a day for 4 months.

Coal, 25 bushels a day, making 85 chaldrons in 122 days, at \$10 a chaldron, - - - -	\$850 00
Engineer per year, - - -	600 00
Firemen for 4 months, - - -	375 00
Wear and tear, - - - -	1,000 00
	<hr/>
	\$2,825 00

Making the whole yearly expense $2825 + 4000 = \$6825$, which is equal to a present outlay of \$136,500, which added to the above sum of \$197,000, makes the sum of \$333,500.

Cost of pumping by steam alone.

Engines, - - - - -	\$70,000 00
Buildings, - - - - -	20,000 00
Water Right, - - - - -	15,000 00
Yearly expenses as in a subsequent estimate E.	
\$11,808=a present capital of - - -	236,160 00
	<hr/>
	\$341,160 00

We see, therefore, that the plan of pumping by water, as far as it can be obtained, and making up the deficiency by steam, has but a very small advantage over that of pumping wholly by steam, even if we assume that the water power will be sufficient for the whole supply during eight months. There is some doubt, however, whether the water power will be sufficient for the eight months, and this added to the perplexity to the city government in the greater complication of works, leads us to prefer steam power alone.

ESTIMATE MARKED D.

Cost of supply from Charles River.

Cost of Reservoirs on Corey's Hill.

Reservoir on Corey's Hill, in two basins 50 feet surface width each, and 864 feet long—10 feet depth of water.

Excavation 36,288 cubic yds.

Extra for puddling 5,100—41,388

yds. a 20 cts. - - - - - 8,277 60

Puddling 4780 cubic yds. a 50 cts. 2,390 00

Slope walls $21 \times 4 \times 864$ for sides,
3,068 perch a \$2 00 - - - 6,136 00

Berm and back drain 8,640 yds. -
20 cts. - - - - - 1,728 00

Discharging pipe 200 feet, 6 inch
and 2 cocks, - - - - - 472 80

Land for above reservoirs together
with land over which the pipe
shall pass, - - - - - 3,949 60 22,954 00

Damage to water rights at Charles
River, being the right to take
water for the supply, above the
lower falls in Watertown, -

15,000 00

Amount carried forward,

\$37,954 00

<i>Amount brought forward,</i>		\$37,954 00
Main pipe from Reservoir on Corey's Hill, to Reservoir on Beacon Hill,		
Two branches of pipes 40 feet long each, 22 inches diameter, with stop cocks for drawing water from Reservoirs to main, cost laid, - - - - -	1,226 24	
Main pipe from Corey's Hill over the Mill-dam, and across the Common and up Tremont and Beacon streets, to Reservoir on Beacon Hill; distance 20,485 feet. Length of pipe including laps at the joints 21,690 feet,—diameter 21 $\frac{1}{4}$ inches, weight per foot, 208 63-100 lbs. at 3 $\frac{1}{2}$ cts. per pound, - - - - -	158,380 38	
Digging trench 6 feet deep, 4 $\frac{1}{2}$ feet wide, 20,485 cubic yards, at 18 cts. a yard, - - - - -	3,687 30	
Filling trench and restoring road after the pipe is laid, 14 cts. a foot in length, - - - - -	2,867 90	
Lead for filling joints 120,500 lbs. at 6 $\frac{1}{2}$ cents. - - - - -	7,832 50	
Laying pipe, including filling lead, \$2 00 a joint, 2,410 joints, -	4,820 00	
Extra for crossing the sluices on the Mill-dam, and for culvert on the Brighton road, - - - - -	9,193 00	
5 Stop cocks at \$212 each—setting and lead \$10 37 each, -	1,111 85	
Air cocks, - - - - -	160 00	189,279 17
<hr/>		
Main pipes 21 inches diameter from Steam works at the lower dam in Watertown to Reservoir on Corey's Hill, distance 16,910 feet (3 $\frac{1}{4}$ miles) \$8 57 a foot, including cost of pipe, lead, excavation, and all expenses of laying the same, - - - - -	144,918 00	
4 Stop cocks and laying the same, - - - - -	888 00	145,806 00
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<i>Amount carried forward,</i>		373,039 17

Amount brought forward,

373,039 17

Two steam engines (each 76 horse power) 48 inches cylinder, 9½ feet stroke, with 2 pumps, 18 inch cylinders, 8 feet stroke to each pump, which will deliver with ordinary use, 2,500,000 gallons of water a day to the Reservoir on Corey's Hill at \$35,000 each,	70,000 00
Buildings for steam engines and pumps including coal houses and shops, and tools for small repairs,	20,000 00
Canal to take the water from the river to the engine pumps, - -	800 00
Guard Gate and Strainer, - -	1,200 00
	2,000 00
	<hr/>
	\$465,039 17
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Instead of crossing the Mill-dam as proposed in the above estimate the supply may be brought by another line, passing from Corey's Hill through Roxbury and over Tremont Street to Beacon Hill. This from its greater length will require that the pipe be 22 inches diameter, and the cost as shown in the following estimate.

Main through Roxbury.

2 branch pipes 40 feet each=80 feet of 22 inch with lead and laying, leading from Reservoir to main, -	1,226 24	
25,051 feet pipe, 22 inch diameter a \$7 56, - - - -	189,385 56	
Digging trenches 4½×6=23,660 cubic yds. a 18 cts. - - -	4,258 80	
Refilling trenches 4½×6=23,660 cubic yds. a 14 cts. - - -	3,312 40	
Lead for 2,783 joints 72 lbs, each, a 6½ cts. - - - -	13,024 44	
Laying pipe at \$2 00 per joint, -	5,566 00	
2 bridges on Tremont Road \$1,500		
1 Culvert in Brookline \$1,500 -	3,000 00	
5 stop cocks \$1,111 85—Air cocks \$160 00, - - - -	1,271 85	\$221,045 29
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The cost of this line is \$31,766 more than the line over the Mill-dam. If it be followed however, a saving of \$21,287 for

the distribution at the south part of the city and for South Boston, as specified in the estimate for distribution, as having been accidentally omitted in the general summary in the body of the report, will be made. We retain the line across the Mill-dam, however, in the Report.

PAPER MARKED E.

Cost of Pumping.

The following are the dimensions of an engine called "little engine," used at the united mines in Cornwell.

Cylinder, 30 inches diameter. Length of stroke, 9 feet. It moves two pumps, one of 12 inches diameter, the lift being 31 feet, and one of 14 inches diameter, the lift being 205 feet. Consequently, the load on both pumps is 15,219 pounds. The length of stroke in the pumps is $7\frac{1}{2}$ feet, and the number of strokes made in April 1835, was 444,620, or 10.29 a minute, without any allowance for rest. Hence it raised $15,219 \times 7\frac{1}{2} = 114,142\frac{1}{2} \times 444,620 = 50,750,038,350$ pounds 1 foot high, during the month. The consumption of coals was 764 bushels; therefore, each bushel raised 66,426,751 pounds 1 foot high.

Should the plan of pumping from Charles River, or Mystic Pond be adopted, we are of opinion that two engines should be erected, each capable of raising 2,500,000 gallons in 20 hours. This would sufficiently ensure one of the engines being always in order, so that a failure of supply to the city, would very rarely, if ever happen. In order to raise this water from Charles River to the reservoir on Corey's Hill, the engine must not only overcome the resistance of the head, 117 feet, but likewise the friction of the horizontal or inclined pipe, $3\frac{1}{4}$ miles long, from Watertown to Corey's Hill. The quantity of this resistance from friction, will depend upon the size of the pipe. With a pipe of 21 inches diameter, as given in the estimate, if the pressure in the pump be equal to a column 150 feet high, or 33 feet above the reservoir on Corey's Hill, into which the water is to be discharged, our formula gives a discharge of nearly 5 cubic feet a second, or 2,700,000 gallons in 20 hours. It will be enough for the present purpose then, to take the engines to work against a column 150 feet high. We have then, 2,500,000 gallons, equal to 20,000,000 pounds to be raised 150 feet high each day, or 3,000,000,000 pounds raised 1 foot. Taking the duty of the engine at 60,000,000 pounds to each bushel of coal, we have 50 bushels per day for the whole consumption.

The engines should have cylinders of 48 inches diameter, 9½ feet stroke, with two pumps each, 18 inches diameter, 8 feet stroke. The area of both pumps being 3.54 feet, 10 strokes a minute, would produce the effect required. We estimate the cost of each engine with the pumps complete, at \$35,000.

We have seen that the consumption of coal will be 50 bushels a day, making 507 chaldrons a year, the price of which may be very safely taken at \$10 a chaldron. The cost of fuel then will be \$5,070 a year.

A very liberal allowance for attendance will be. One principal engineer or superintendent, with a salary of \$1,000 a year, and five men as engineers and firemen, at \$1 50 a day each, making in all \$2,738 a year.

The cost of providing new parts for the engines and pumps as they shall wear out, and for such repairs as will not be done by the workmen constantly employed, whose pay is in the preceding item, together with the cost of oil and insurance, may be taken, safely, at \$3,000 a year.

We have then,

Coal, - - - -	\$5,070 00
Superintendent, - - -	1,000 00
Engineers and Firemen, -	2,738 00
Wear and tear, insurance, &c.	3,000 00

\$11,808 00 annual expense for
pumping.

ESTIMATE MARKED F.

Cost of supply from Mystic Pond.

Dam at the outlet of the pond, -	\$2,000 00	
Canal, Gates, and Strainer, to take the water from the pond to the pumps, - - - - -	2,000 00	4,000 00
Reservoir on Walnut tree Hill, 250 feet square, 10 feet deep, -	13,000 00	
Land at Mystic Pond, and for re- servoir at Walnut tree Hill, to- gether with land on which the pipe shall pass to Boston, -	5,500 00	18,500 00
<i>Amount carried forward,</i>		<u>22,500 00</u>

<i>Amount brought forward,</i>		22,500 00
Main pipe, 18 inches diameter, from the engine station, near Mystic Pond to the reservoir on Walnut tree Hill, distance 8,250 feet, at \$7 33 a foot, including lead, trenching, and all expenses of laying, - - - - -	60,472 00	
Main pipe, 22 inches diameter, from Walnut tree Hill, to reservoir on Beacon Hill, distance 39,707 feet, at \$9 02 per foot laid, including lead, trenches, laying the pipe and refilling trench,	358,157 00	418,629 00
Stone bridge to carry the pipe across Charles River, - - -	14,000 00	
Arches and additions required to cross over the sluice gates of the Mill-dam, - - - - -	8,493 00	
Two Culverts, - - - - -	1,000 00	23,493 00
Two Steam engines (76 horse power each) cylinders 48 inches diameter, 9½ feet stroke, with 2 pumps, each 18 inches diameter, 8 feet stroke, which will deliver with ordinary use, 2,500,000 gallons of water a day, to the reservoir on Walnut tree Hill, \$35,000 each, - - - - -	70,000 00	
Buildings for steam engines and pumps, including coal houses and shop, and tools for small repairs,	20,000 00	90,000 00
		<u>\$554,622 00</u>

ESTIMATE MARKED G.

Cost of supply from Spot Pond united with Mystic Pond.

Main pipe, 22 inches diameter from Spot Pond to Reservoir on Wal-

nut tree Hill, distance, 16,789 feet, $3\frac{179}{1000}$ miles at \$9 02 a foot, including lead for joints trenching and laying pipe and refilling trench, - - - - -	\$152,436 00
Rock cutting in trench near the Pond, - - - - -	1,007 00
Dam and apparatus for taking water from Spot Pond, - - - - -	1,200 00
Stone bridge to carry pipe across Medford River, - - - - -	5,000 00
Reservoir on Walnut tree Hill, 250 feet square, 10 feet deep, - -	13,000 00
Main pipe, 15 inches diameter, from pumping works at Mystic Pond to Reservoir on Walnut tree Hill, distance 8,250 feet, ($1\frac{562}{1000}$ miles,) at \$4 32 per foot laid, including cost of lead, trenching and laying, -	35,640 00
Steam engine, (76 horse power,) cylinder 48 inches diameter, stroke $9\frac{1}{2}$ feet, with 2 pumps, 18 inches diameter, 8 feet stroke, capable of delivering 2,500,000 gallons of water a day to the Reservoir on Walnut tree Hill, -	35,000 00
Building for steam engine and pumps, including coal house and shop and tools for small repairs, -	10,000 00
Main pipe, 22 inches diameter, from Walnut tree Hill to Reservoir on Beacon Hill, distance 39,707 feet, $7\frac{52}{100}$ miles at \$9 02 per foot laid, including lead for joints, trenches, laying the pipe and refilling trench, - - - - -	358,157 00
Stone bridge to carry pipe over Charles River, - - - - -	14,000 00
Arches and additions required to cross the sluiceways at the Mill-dam, - - - - -	8,493 00
Two culverts, - - - - -	1,000 00
Land for Reservoir on Walnut tree Hill, and at the engine house in	

Amount carried forward, .

\$634,933 00

<i>Amount brought forward,</i>		\$634,933 00
Medford, together with land over which the pipe shall pass, added to our assumed value of Spot Pond, - - - - -	80,000 00	80,000 00
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		\$714,933 00

Yearly cost of pumping 650,000 gallons a day for six years, but which, for the purpose of distributing the expense through the whole period of ten years, we take at 390,000 a day for ten years.

Engineer, who will remain always at the works and keep the engine in order at all times for use, -	\$800 00	
The supply will be furnished by the engine working constantly for 48 days, but it will perhaps be more convenient to work in the day time only, for, say, 100 days. This will require 2 firemen or assistants to the engineer at \$1 50 each per day, - - - - -	300 00	
Coal to raise 390,000 gallons a day, or 142,350,000 a year, 150 feet high, 79 chaldrons at \$10 00 per chaldron, - - - - -	790 00	
Wear and tear, beyond that which will be made good by the engineer constantly employed, and paid as above, together with oil, and small expenses, and insurance, - - - - -	1,000 00	2,890 00
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		\$2,890 00

PAPER MARKED H.

Showing the durability of Iron Pipes.

Extracts from minutes of Evidence taken before the select Committee of the House of Commons, on the supply of water to the Metropolis in 1821.

Evidence of William C. Mylne, Esq., Engineer to the New River Company.

Q. Have there been any experiments made at any time respecting iron pipes, that ascertain the extent of their durability? A. None have worn out yet, they have been down 30 or 35 years. I have seen parts of pipes that have been 80 years under ground, perfectly good.

They corrode in some places, but not in others, that depends upon the soil in which they are put? Yes.

Have you seen any instance of decay in the iron pipes? Nothing worth mentioning.

Have you ever known any expense incurred in repairing iron pipes? There is a small expense: there is a contraction and expansion takes place with every change of the season, and when they were screwed together they become one rod, and pulled themselves asunder every winter; now passing into each other with socket joints, the effect of expansion is not perceivable.

They are not screwed together now? No; the contraction on nine feet is so small, it does not affect the joint.

Evidence of THOMAS SIMPSON, Esq., Engineer to the Chelsea Company.

Q. How long will a wooden pipe last, according to your experience? A. According to my calculation, upon an average fifteen years.

What experience have you had of iron? Forty years, and I have taken up and relaid iron that had been down forty years before.

Have you found any corrosion in those pipes? None whatever.

And is the water as good coming through iron pipes? Quite.

You have had experience of iron pipes eighty years? I have taken up a pipe that had been forty years in the ground, and put it down again.

[The following papers were delivered in, and read.]

February 24th, 1821.

In respect to the durability of cast iron pipes in the streets of London, I believe there exists no difference of opinion; all the persons with whom I have conversed being confident that they will be as perfect at the expiration of 100 years as they were in the first instance, but how far the joints will remain perfect, and the pipes answer all the purposes for which they were intended,

is a very difficult point to determine, from their having been in use so short a time.

From the experience I have had I consider the capital expended in the pipes to remain unalterable, having seen some which had been in use eighty years, so perfect that no corrosion was visible, but the contraction and expansion of the metal, with the temperature of the water with which they are filled, is constantly acting on the joints, the effects produced from which, in my opinion, will be equal to a complete relay in every thirty years; for it must be considered, that as all such repairs must be executed without interfering with the supply of the town, it must therefore, be done under every disadvantage.

It is also necessary to observe, that the velocity with which the water passes through the pipes, materially affects their future efficiency. In all pipes that I have seen, immediately connected with engines, I have observed no material incrustation, there being nothing more than a thin film on the surface, resembling what is produced in the interior of a tea-kettle, but in pipes, where the velocity is not so great, a material incrustation takes place, and more particularly with Thames-water.

In the New River water works, I have seen a sixteen inch pipe taken up, which had been down about twenty years; it was reduced from incrustation, at least one inch in the diameter.

In Kensington Gardens, I understand a five inch service pipe was laid down of iron, in the year 1751, and it was in 1819 taken up from inefficiency, being reduced to about three inches in diameter in many parts of its length, which consequently affected the utility of the whole. A similar circumstance happened at Windsor palace.

These are the only instances with which I am acquainted, but if such should be the case with all the pipes in the streets of London, there will not only be an annual expenditure in coals (or other ways) to overcome the temporary resistance arising from such incrustation, but also a complete relay, for the purpose of cleansing, once in about fifty years.

I must also observe, on the capital employed in cocks, which is by far the most perishable, a considerable part of them being made of wrought iron, from the experience I have had, the screws will all require to be renewed within seven years, and the doors fresh faced, which may be considered as being equal to a complete renewal of that portion of the capital in every ten years.

(Signed) WILLIAM CHADWELL MYLNE.

February, 1821.

In my evidence of Friday, the 16th instant, in answer to a question respecting the duration of iron pipes, I stated "that iron pipes would not require repairs." This question I understood related to the time that iron pipes would last, without a reference to the repairs, and I beg to state there will be an expense attendant on the repairs of iron pipes. With respect to their duration, I have not had sufficient experience to fix a period, but what I have taken up, did not appear to be diminished in substance.

The following are three particular instances of the construction of the orifices of iron pipes, which came under my observation :—

In the year 1789, in consequence of the great difficulty experienced in supplying Windsor Castle with water, I was ordered by the surveyor general of his Majesty's office of works, to ascertain the cause, if possible. The engine which supplies the castle is working by the fall of the river Thames, and the pumps are supplied from a spring. Upon examination, I found the leaden conveyance pipe for the engine to the castle, very defective, and recommended two and a half inch iron pipe to be substituted, which was done. In the year 1816, the same deficiency of supply took place as in 1789, but not from the same cause. I had, from my observations, experienced the incrustation of iron pipes, and concluded the pipe was almost stopped; and having recommended the pipe to be taken up, I ascertained the orifice was little more than one inch in diameter, the incrustation being nearly equal all round the internal surface of the pipe.

In the year 1791 it was found necessary to take up and relay a twelve inch iron main (of flanch pipes, which were originally laid down in the year 1746) from the Chelsea water works engine to the Reservoir in Hyde Park, in consequence of the joints being perished. The incrustation on the internal surface of this main was in irregular lumps, and upon an average about half an inch thick; the diameter of the pipe being contracted to nearly eleven inches.

In the year 1819 the difficulty of supplying the Reservoir in Kensington Gardens, near the palace, had increased to such an extent, that it became absolutely necessary to ascertain the cause; and having taken the proper steps, I found the pipe was contracted by incrustation. The pipe was originally five inches diameter; and from the Chelsea water work books was laid by government in the year 1751. The pipe was contracted to three inches diameter, and the incrustation covered the internal surface in irregular lumps.

From the foregoing observation an inference may be drawn, that the incrustation on the internal surface of iron pipes will, in the course of fifty years, so contract the orifices, that it will be absolutely necessary for the pipes to be taken up, cleaned and relaid, during which process some of them may be injured. It had long been discovered, in the instance of the pipe which supplies the Reservoir in Kensington Gardens from the Chelsea water works main, that great difficulty had arisen in making the service, and the cause was unknown until the pipe was examined, so that the incrustation had, it must be presumed, originated some years before that period. It is necessary to observe, that by the progressive incrustation and consequent contraction of the orifices of the pipes, the friction of the water passing through them will be increased, and either a greater power or longer time will be required to force the same quantity of water through iron pipes at the end of fifty years, than was originally allowed. Upon this computation it may be stated, that the progressive requisite increase of power or of time, will occasion a corresponding increase of expense, which in the fiftieth year may amount to fifty per cent. more than was found sufficient in the first year. It is also necessary to observe, that this process of incrustation in iron pipes is calculated upon a supposition that the River Thames water only is used in the pipes.

(Signed) THOMAS SIMPSON,
Inspector General to Chelsea Water Works.

February 24th, 1821.

Thomas Simpson, Esq., continued.

Q. You were the inventor of the spigot and fosset joint ?

A. I was.

How long ago did you lay them down ? I tried some experiments six or seven and thirty years ago, and then I laid a long main for Chelsea water works.

And you have never found them want repair ? Those that were laid down for the Chelsea water works were taken up and relaid after twenty-seven years, but the first that I laid down, had been laid down six or seven and thirty years, and I never knew them fail yet.

Was this experiment on a large scale ? No ; the first I tried was with some joints we could not make stand in any other way ; and we run them in lead and it has not failed.

Is it upon a large scale ? No, it was one joint I tried.

You still use the oakum behind the lead ? Yes.

You tried one joint at first ? Yes ; it answered for seven

years and never leaked ; and then I ventured on laying a main, perhaps, 1,500 or 1,600 yards, for the Chelsea water works.

How long ago was that ? They had been down twenty-seven years ; they were taken up two years ago, and relaid in Pall Mall.

This main was down about twenty-seven years ? Yes ; about 1,500 yards long.

New joints were put to them when they were relaid ?

They were relaid in Pall Mall, then they were joined in the same manner with lead.

When you took them up you found no defects in the joints ? None whatever.

And they had been down twenty-seven years ? Yes.

Your experiment of thirty-seven years does not go beyond one joint ? Two or three joints, perhaps, I tried the experiment on.

William Anderson, Esq., Engineer to Grand Junction Company.

Q. You have spoken of the decay of a particular pipe which had begun to oxydate or rust ; was it owing to its being in calcareous or siliceous earth ? A. No, I think not ; but it was the inside of the pipe that oxydated.

It is probable that iron pipes might not decay in argillaceous earth ; have you ascertained how it will be in calcareous earth ? No, I have not ; it is more from the interior of the pipe that we expect decay.

Have you had many instances of the bursting of a pipe ? We have had a few.

That is an accident which occasionally happens to iron pipes ? Yes ; but it is occasioned by frost when it does take place, from the contraction.

In point of fact, have you had many pipes burst ? We have had a few.

(Note by Commissioners.)

The expense of relaying, will not probably exceed 20 per cent. on the whole first cost of the pipes, laid, and as this will not require to be done, according to the above evidence, under at least 40 years, it is too inconsiderable to form any serious objection to iron pipes.

PAPER MARKED I.

Boston, September 2, 1837.

DANIEL TREADWELL,
 JAMES F. BALDWIN,
 NATHAN HALE, ESQUIRES, } Commissioners, &c.

GENTLEMEN,

The President and Directors of the Middlesex Canal have considered your communication, dated August 22d, in which this question is proposed : " What sum of money will be taken by the proprietors of the Canal, as a compensation for all damage they may sustain from the Water of Long Pond being diverted from its present course ?"

This pond is the main source of Concord River ; the river is the source of the canal throughout its length. The total diversion of the water of the pond would probably deprive the canal of nearly all its water. A partial diversion would sometimes produce nearly the same effect, that is, in dry seasons, when there is not a drop to spare, if the canal be kept in use. One of your number is, perhaps, better informed than this board is, on this subject.

As the inquiry goes to the full extent of the whole value of the canal, in some views, it would be exceedingly difficult to state a sum as a compensation. It would be, first, necessary to know precisely, what quantity of water your proposed object would divert ; and then to know what effect that diversion might have on the canal's interest.

Acting only representatively, this board cannot speak with any authority as to the views of the proprietors, this subject not being within the commonly delegated powers. But speaking individually, the members beg leave to say, that anything within their power, tending to accomplish the valuable purpose of your commission, will be most willingly undertaken by them.

Most respectfully, gentlemen,

Your obedient servant,

PETER O. THACHER,

President of the Corporation of Middlesex Canal.

ESTIMATES MARKED J.

Cost of supply from Long Pond.

Aqueduct from Long Pond to Corey's Hill in Brookline.

Aqueduct of brick, as shown fig. 1 on plan, Iron pipe across Charles River and Brighton valleys.

Open Canal next Pond, 2,000 feet=18,518 cubic yards, a 20 cents. - - - - - \$3,703 60

Earth work in the 25 sections, exclusive of mud cutting for base of embankments, all the embankments and excavation for pipes as follows.

	Price.	Cubic Yards.	Cost.
Earth cutting, at 10 cts.		1,493	149 30
“ “ 15 “		38,552	5,782 80
“ “ 16 “		91,258	14,601 28
“ “ 17 “		129,420	22,001 40
“ “ 18 “		420,740	75,733 20
“ “ 19 “		15,291	2,905 29
“ “ 20 “		15,336	3,073 20
Rock cutting “ \$1 25		12,199	15,248 75

139,495 22

Mud cutting for base of Embankments, the Embankments and excavations for pipes, as follows,

Mud cutting, &c. at 15 cts.	56,013	8,401 95
“ “ “ 16 “	2,275	364 00
“ “ “ 17 “	33,007	5,611 19
“ “ “ 20 “	32,349	6,469 80

20,846 94

Back filling over brick work in

earth cutting, - - - -	18,615 50
Back filling in rock cutting, -	400 00
Back filling in pipe sections, -	258 60

19,274 10

Brick Work.

Form, cylindrical, thickness 8 inches, interior diameter, 4.60 feet—14.44 feet circumference on inside—mean circumference 16.54 27,250 bricks to 100 feet lineal. Open area of cross section $16\frac{1}{4}$ feet.

Bricks delivered at Worcester rail road, per 1,000 - - - - - \$8 00

Carrying on rail road, and carting per 1,000 - - - - - 1 00

Equal to - - - - - 9 00

Amount carried forward,

\$183,319 86

<i>Amount brought forward,</i>		\$183,319 86
Hydraulic lime $2\frac{1}{2}$ casks to 1,000 bricks,		
Cost in Boston per cask, \$3 00		
For delivery on line, 16		
	3 16 per cask.	
$\$3,16 \times 2\frac{1}{2} = \$7,90$ for lime to		
1,000 bricks, - - - -	7 90	
Laying bricks and tending,		
per 1,000 - - - \$3 33		
4 cubic ft. sand to 1,000 bricks		
per 1,000 - - - 15		
Puddling about brick work,		
per 1,000 - - - 22		
	<u>3 70</u>	
Whole cost per 1,000 bricks, \$20 60		
Equal to—\$561 $36\frac{1}{2}$ per 100 feet, which multi-		
plied by 52.8=\$29,640 per mile, 15 miles and		
1,600 feet, - - - -		\$453,581 00
2 sections of pipe across the valleys,		
30 inch diameter, 2,470 feet, =		
(including slopes and laps,) 2,692		
feet, at 11 $30\frac{1}{2}$ per foot, - -	\$30,453 00	
Lead for 299 joints, at 127 lbs.		
each=37,973 lbs. lead at $6\frac{1}{2}$ cts.	2,468 24	
Laying and leading 299 joints at		
\$2,00 = - - - -	598 00	
	<u>33,499 24</u>	
Guard Gates and Strainer, - -	1,200 00	
Bridge over Charles river, - -	11,108 00	
Other bridges and culverts, - -	6,160 00	
	<u>18,468 00</u>	
Water rights, land and land damages, - -		110,000 00
8 openings for letting off water, at		
\$718 each, - - - -	5,744	
15 Ventilating Pipes, at \$20, -	300	6,044 00
Branches and Gates at mouth of Aqueduct for		
discharging into the 2 portions of Reservoir, -		1,436 00
	<u>Whole cost of Brick Aqueduct from Long Pond</u>	
to Corey's Hill, - - - -		\$806,348 10
If built of stone as shown at fig. 2 on plan.		
Open Canal next pond, 2,000 feet, = 18,518 cu-		
bic yards, at 20 cents, - - - -		3,703 60
<i>Amount carried forward,</i>		\$3,703 60

<i>Amount brought forward,</i>			\$3,703 60
Earth work in the 25 sections, exclusive of mud cutting for base of embankments, all the embankments and excavation for pipes, as follows,			
	Price.	Cubic Yards.	Cost.
Earth cutting, at 10 cts.		2,380	238 00
" " 15 "		72,327	10,849 05
" " 16 "		162,477	25,996 32
" " 17 "		190,554	32,394 18
" " 18 "		561,431	101,057 58
" " 19 "		30,190	5,736 10
" " 20 "		28,027	5,605 40
Rock cutting, \$1 25		14,330	17,912 50
			<hr/>
			199,789 13
Mud cutting for base of embankments, the embankments, and excavation for pipes, the same as for brick structure, - - - -			
			20,846 94
2 sections of pipe across the valleys, 30 inch diameter, 2,470 feet, (including slopes and laps)			
2,692 feet, at \$11 30½ per foot, \$30,433 00			
Lead for 299 joints, at 127 lbs.			
each, = 37,973 lbs. at 6½	-		2,468 24
Laying and leading 299 joints, at			
\$2 00 each, - - - -	-		598 00
			<hr/>
			33,499 24
Guard Gates and Strainer, - -			
			1,200 00
Bridge over Charles River, -			
			11,108 00
Other Bridges and Culverts, -			
			6,160 00
			<hr/>
			18,468 00
Back filling over stone work in earth cutting, - - - -			
			18,615 50
Back filling over stone work in rock cutting - - - -			
			400 00
Back filling in pipe sections, -			
			258 60
			<hr/>
			19,274 10
<i>Stone Work.</i>			
Form—rectangular—side walls 4 feet a part, 2½ feet high and 1½ feet thick, with a semicircular arch covering, 2 feet radius, area of cross section 16¼ feet. Bottom formed of 3 stones 1 foot thick. Those under the side walls 3½ feet long. Middle one, 2 feet long.			
Bottom and side walls, per foot lineal, 16.50 cubic feet.			
Arch	do.	12.95	cubic feet.

Amount carried forward,

\$295,581 01

<i>Amount brought forward,</i>		\$295,581 01
Bottom and side walls, at \$3 00 per perch, 1 98 pr. foot in length.		
Arch at \$4 00 per perch, 2 07 pr. foot in length.		
Cost pr. foot in length,	\$4 05	
Cost of stone work laid per 100 feet at 4 05 pr. foot, is \$405 00.		
Cost of ditto per mile, is \$21,384		
Puddling clay 31 cubic feet—Gravel 14 cubic feet per foot in length.		
Cost of clay 75 cts. a cubic yard=86 cents and gravel 33 cts. a load=17 cts. a foot lineal— making \$1.03 a foot lineal. Mixing clay and putting it about the stone 40 cts. a foot. Put- ting gravel into trench, and packing about the stone 12 cts., making 40+12=52 cts. Mak- ing for puddling per foot \$1.55—per 100 feet (\$155.×52.8) per mile=	\$8,184 00	
To which add stone work per mile,	21,384 00	
Gives cost of stone structure per mile, - - - - -	\$29,568 00	
15 miles and 1,600 feet of stone Aqueduct at \$29,568 00 pr. mile,		452,480 00
8 openings for letting off water at \$718 00 each, - - - - -	5,744 00	
15 ventilating pipes a \$20 00 each,	300 00	
Water rights, land and damages, -	110,000 00	
Branches and gates at mouth of aqueduct for discharging into the 2 portions of Reservoir, -	1,436 00	117,480 00
Whole cost of stone aqueduct from Long Pond to Corey's Hill, - - - - -		\$865,541 01
Reservoir on Corey's Hill, as in estimate marked D.		
Excavation, - - - - -	\$8,277 60	
Puddling, - - - - -	2,390 00	
Slope Walls, - - - - -	6,136 00	
Berm and back drain, - - - - -	1,728 00	
Discharging Pipe, - - - - -	472 00	
<i>Amount carried forward,</i>		\$19,003 60

<i>Amount brought forward,</i>	\$19,003 60	
Land for reservoir, only, - -	2,000 00	
		21,003 60
Main pipe from Reservoir on Corey's Hill to reservoir on Beacon Hill, as in estimate marked D., - - - - -		189,279 00

Recapitulation.

Brick Aqueduct, - - - - -	\$806,348 10	
Reservoir on Corey's Hill, - - - - -	21,003 60	
Pipe from Corey's Hill to Boston, - - - - -	189,279 00	
		\$1,016,630 70

PAPER MARKED K.

Distribution in the City.

Reservoir on Beacon Hill.

100 feet \times 100 in clear and 10 feet deep.

Excavation 7,260 cubic yds. a 10 cts. over value of earth, - - \$726 00

Wall for foundation of outside wall
13 feet deep $\frac{8 \times 6}{2} = 7$ feet thick
= 38,948 cubic feet at 20 cts. 7,789 60

Foundation walls for bottom of Reservoir. 19 walls 2 feet thick—
100 feet long, 30,400 cubic feet
at 20 cts. - - - - 6,080 00

Bridging or bottom stone 10,000
cubic feet at 30 cts. - - 3,000 00

Outside main walls hewed bed and
build $4 \times 10 \times 424 = 16,960$
cubic feet at 50 cts. - - 8,480 00

Brick bottom 2 courses 90 thousand
" sides 67 "

	157 m. at		
\$20 per m laid, - - -		3,140 00	
Roof of Wood (Slated,) - - -		3,124 00	
Land for Reservoir, - - -		39,200 00	\$71,539 60

Amount carried forward, \$71,539 60

<i>Amount brought forward,</i>		\$71,539 60
Reservoir on Fort Hill.		
65 feet clear. To hold 50,000 cubic feet, 15 feet deep.		
1 Concentric division or pier Wall.		
Excavation 3,540 yds. at 20 cts. above the value of the earth, -	\$708 00	
Bricks 245,500 at \$20 laid in cement, - - - - -	4,910 00	
Plastering bottom and sides, -	500 00	
Covering with earth 5 feet deep 712 yds. at 15 cts. - -	\$106 80	6,224 80

Iron Pipes.

20 inch main pipe from Beacon to Fort Hill.		
2,400 feet=2,541 including laps at \$6 53 per foot, - - -	\$16,592 73	
Lead for 282 joints at 60 lbs. each 16,920 at 6½ - - - -	1,099 80	
Laying pipe at \$2 00 per joint -	564 00	
Digging trench and refilling and paving at 30 cts. lineal foot, -	720 00	
3 stop cocks at \$200—\$600, and lead and setting \$38 94, - -	638 94	19,615 47

Whole length of streets, 253,477 feet,
Less, not built upon, 30,000 "

223,477 "

944 feet of 12 inch main at \$3 48 per ft. of pipe, - - - - -	3,285 12	
2,520 lbs. lead, at 6½ cts. per lb. -	163 80	
Laying 105 joints, at \$2, - -	210 00	
		3,658 92
11,954 feet 10 inch main, at \$2 69	32,156 26	
21,264 lbs. lead, at 6½ cts. per lb.	1,382 16	
Laying 1,329 joints, at \$2, - -	2,658 00	
		36,196 42
4,876 feet 8 inch main, at \$1 73,	8,435 48	
7,046 lbs. lead, at 6½ cts. - -	457 99	
Laying 542 joints, at \$1 50 -	813 00	
		9,706 47
22,754 feet 6 inch main, at \$1 36,	30,945 44	
25,290 lbs. lead, at 6½ cts. - -	1,643 85	

Amount carried forward, \$146,941 68

<i>Amount brought forward,</i>		\$146,941 68
Laying 2,529 joints, at \$1,50, -	3,793 50	
	<hr/>	36,382 79
82,056 feet 4 inch service pipe, at		
82 cts. - - - -	67,285 92	
73,080 lbs. lead, at 6½ cts. - -	4,750 20	
Laying 9,135 joints, at \$1,25, -	11,418 75	
	<hr/>	83,454 87
214,712 feet 3 inch service pipe,		
at 60 cts. - - - -	128,827 20	
119,370 lbs. lead, at 6½ cts. -	7,759 05	
Laying 23,874 joints at \$1,25 -	29,842 50	
	<hr/>	166,428 75
Digging and covering 38,650 feet		
of the 12, 10, 8 and 6 inch pipes		
at 30 cts. per foot, - - - -	11,595 00	
285,765 feet 4 and 3 inch service		
pipe, less 41,059 laid by side of		
main, 244,715 feet at 25 cts. -	\$61,178 75	
	<hr/>	72,773 75

Stop Cocks.

2 of 12 inch at \$88 each \$176		
Lead and setting 16		
5 feet 4 inch pipe 4	\$196	
27 of 10 inch - - - -	2190	
12 of 8 " - - - -	812	
54 of 6 " - - - -	2964	
194 of 4 " - - - -	7961	
448 of 3 " - - - -	15,460	
	<hr/>	29,583 00

Fire Plugs.

One to 500 feet of street, 447 at		
\$19, 1,00 each for setting, \$20,00		
each - - - -	8,940	8,940 00

Whole cost of distribution \$544,504 84
 Conveying water to, and distributing it at South Boston.

Main pipe from Washington street, through Northampton street, and over the South Boston Turnpike, to Broadway in South Boston.

12,456 feet 8 inch main, at \$1 73		
per foot, - - - -	21,548 88	
26,296 lbs. lead, 6½ cts. per lb. -	1,709 24	
Laying 1,384 joints, a \$1 50, -	2,076 00	

Amount carried forward, \$25,334 12

<i>Amount brought forward,</i>	\$25,334 12	
Trenching and refilling 11,880 feet, at 20 cts. a foot, - - -	2,376 00	\$27,710 00
8,226 feet of 4 inch service pipe, at 82 cts., - - -	6,745 32	
9,140 lbs. lead, at 6½ cts. - -	594 10	
Laying 914 joints, at \$1 25, -	1,142 50	
Trenching and refilling, at 25 cts. per foot, - - -	1,930 00	10,461 92
8,226 feet of 3 inch service pipe, at 60 cts. - - -	4,935 60	
6,398 lbs. lead, at 6½ cts. - -	415 87	
Laying 914 joints, at \$1 25, -	1,142 50	
Trenching and refilling, at 25 cts. per foot, - - -	1,980 00	8,473 97
Stop Cocks, - - -	1,000 00	1,000 00
		<u>\$47,645 89</u>
Additional pipe for the supply of the south part of the City and South Boston,		
551 feet 12 inch main, at \$3 48 per foot, - - -	\$1,917 48	
1,769 lbs. of lead, at 6½ cts. per lb. -	115 00	
Laying 61 joints, at \$2 00, - -	122 00	\$2,154 48
8,179 feet of 8 inch main, at \$1 73 per foot, - - -	14,149 67	
17,271 lbs. of lead at 6½ cts. per lb. - - -	1,122 61	
Laying 909 joints, a \$1 50, -	1,363 50	16,635 78
Digging 8,325 feet in length, with refilling and paving, at 30 cts. a foot, - - -	2,497 50	<u>\$21,287 76</u>

(The plan of distribution having been originally made on the supposition that the supply would be brought through Tremont Street, this estimate for additional pipes, which will be required in case the supply is introduced by way of the Mill Dam, was accidentally omitted in the recapitulation of the estimate, contained in the report at page 39. In the same recapitulation there was an error in the estimate for lead, being \$5,627, in excess. Correcting the amount as there given, then the distribution will stand, including South Boston, \$673,214, instead of \$657,554.)

PARTICULARS OF ANALYSES OF WATERS.

Roxbury Laboratory, May 24th, 1837.

TO JAMES F. BALDWIN, Esq.,

DEAR SIR—Agreeably to my promise, I hasten to give you in brief, the results of my analyses of the six specimens of water which have been received by me. Some experiments on the vegetable matter contained in several of the samples are in progress, and some time will necessarily elapse before its nature can be fully ascertained. Enough information relative to these specimens to enable you to make a choice of your source of supply from them, it is hoped, is contained in the following. I defer to a future time a more detailed account of their chemical qualities.

With much respect,

(Signed) A. A. HAYES.

Specimen No. 1. [Punkapaug Pond.] A slightly turbid water, of a light yellowish tint, and faint earthy odor, which disappears by exposure to air.

100,000 lbs. of this water give by proper processes, 2,964 pounds measures of mixed gases, composed of

Carbonic acid gas,	-	-	-	-	1988	
Nitrogen	"	-	-	-	904	
Oxygen	"	-	-	-	72	2964

This mode of stating by bulks is preferred to the more usual mode by cubic inches, on account of the ease with which the mind perceives the relation of the dissolved gas to the volume of water assumed.

100,000 lbs. of this water, by slow evaporation, gives a light brown, earth like matter, which dried at 212° F. weighs 3.00 lbs.

When this matter is heated, the vegetable remains are burnt, and there remains of solid matter, but 1.20 lbs.

1.20 lbs. by careful analysis, afford

Of Sulphate of Lime (Gypsum)	-	0.32 lbs.	
Sulphate of Soda (Glaubers Salt)	}	0.36	
Chloride Sodium (Common Salt)			
Muriate Magnesia (Bittern)		0.08	
Silicious earth with clay,		0.27	
Unconsumed coal and trace of Oxide of iron,		0.24	1.20 lbs.

No. 2. [Neponset River.] The color of this specimen was nearly the same as No 1, its odor was less distinctly earthy.

100,000 lbs. contain of mixed gases, 2,386 pounds bulk.

Consisting of Carbonic acid gas,	289
Nitrogen	2025
Oxygen	72

Of saline matter, dried at 212° F. 5.24 lbs. when ignited for
destroying vegetable matter, 2.47

Containing Sulphate of Lime,	0.34
Sulphate of Soda and } Chloride of Sodium }	0.42
Carbonate of Lime,	0.40
Silicious earth, clay and magnesia,	1.31
	<hr/>
	2.47

No. 3. [Spot Pond.] Nearly colorless, no odor.

100,000 lbs. contain of mixed gases, 2892 pound bulks.

Consisting of Carbonic acid gas,	1084.6
Nitrogen “	1355.6
Oxygen “	451.8

Of matter well dried at 212° F. 1.80 lb. which becomes of dry saline matter, 1.01 lbs. consists of

Sulphate of Soda,	0.252	
Sulphate of Lime,	0.060	
Carbonate of Lime and silicious earth,	0.635	
Chloride of Sodium,	0.063	1.010

No. 4. [Charles River.] Nearly colorless, has no perceptible odor, is more brisk and sparkling than either of the specimens.

100,000 lbs. give by repeated trials, 3,741 pound bulks of mixed gases, which were decomposed into Oxygen, 2040
Nitrogen, 1701

A trace of carbonic alid only, can be observed, the excess of Oxygen is an unusual fact: 3.32 lbs. result from the evaporation of 100,000 lbs. at 212° F.

This weight is reduced by heating to 1.80 lbs. consisting of

Sulphate of Soda,	$0.06 \times 2 = 0.12$ lbs.
Chloride of Sodium,	$0.29 \times 2 = 0.58$
Carbonate of Lime, .	$0.42 \times 2 = 0.84$
Siliceous earth, clay and trace } iron and magnesia,	$0.13 \times 2 = 0.26$

For 50,000	90	1.80
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No. 5. [Long Pond.] Resembles No. 4, in physical prop-
erties.

100,000 lbs. contain of mixed gases, 2,169 pound measures of foreign and saline matter, dried at 212° F. 3.033 lbs. at redness, 2.108 lbs.

		By weight of each ingredient,	
100,000 lbs. by pound bulks,	Sulphate of Lime,		0.193
Carbonic acid gas, 361	Chloride of Sodium,		0.533
Nitrogen " 1627	Carbonate of Lime,		0,266
Oxygen " 181 2169	Silicious earth, clay, }		1.100
	and magnesia,		
	Sulphate of Soda,		0.016
<hr/>			
			2.108

No. 6. [Farm Pond.] In color is darker than well water, it has no odor or taste.

100,000 lbs. afford of mixed gases 3,000 pound measures, or Nitrogen gas, 2,710. Carbonic acid, in very small proportion is present. Its bulk could not be ascertained. Oxygen gas, 290.

100,000 lbs. evaporated to dryness at 212° F., leave 5.36 lbs. The vegetable matter being consumed, 4.46 lbs. of light earthy matter remains.

This separated into its constituents, gives of

Carbonate of Lime,	1.20	
Sulphate of Soda,	0.30	
Chloride of Sodium,	0.56	
Silicious earth and clay,	2.40	4.46

Each sample of water operated on weighed over 7 lbs. avoird. In cases of doubtful accuracy, two trials were made, and separate portions of water were at all times used for discovering what substances were contained. The extreme purity of the specimens has much retarded the experiments.

(Signed)

A. A. H.

Boston, February 5, 1837.

Chemical examination of water from an Artesian Well of South Cove Hotel, Boston.

The water in question was brought to me by Mr. N. Hammond. It was observed to be white and milky when first brought to me, from the presence of particles of marly clay, suspended in the water. In the course of 24 hours, this subsided to the bottom of the bottles, and the clear water was poured off, for chemical analysis. By the usual process of testing, I found it to contain

Chloride of Sodium, or common Salt.

Chloride of Calcium, or muriate of Lime.

Sulphate of Lime, or Gypsum.

Carbonate of Lime, dissolved by carbonic acid.

Carbonate of Iron, " " " "

Animal matter.

A pint of this water evaporated to dryness, in a glass basin, left seven grains of saline matter of a brown color. During the evaporation, a very thin crust of carbonate of lime, formed on the inner surface of the glass. The saline contents of this water are such as are commonly found in the water of superficial wells in Boston. I do not know how much influence the crust formed on boiling this water will have on the Locomotive Engine boilers, but suppose, unless some means are devised to clean them occasionally, they will become encrusted with calcareous matter, just as our tea kettles, in this city, become encrusted, by this deposit from the common well water. It is easy for you to calculate by the proportion contained in one pint of this water, how much will be deposited by this water used in an engine per diem. The crust formed by boiling one pint is equal to about one grain of carbonate of lime, and if the water is evaporated to dryness, each pint will deposite 7 grains of saline matter, about half of which amount may be re-dissolved, on introducing fresh water into the boiler.

Your ob't serv't,

(Signed) CHARLES T. JACKSON.

No. 21 Green Street.

Result of a chemical analysis of the water from an Artesian Well in the work shop of the Worcester Rail Road Corporation.

The water which was the subject of these experiments was quite turbid, from the suspension of a grayish white, minutely divided matter, resulting from the decomposition of micaceous rocks. When the suspended matter had subsided, a clear, colorless, and tasteless water was obtained. There was present the usual quantity of gaseous matter, the nature of which could not be ascertained, from the specimen sent having been exposed, but no noxious gas was found.

10,000 lbs. of this water, contain of foreign substances, exclusive of all water, only $7\frac{82}{100}$ lbs. or less than $\frac{8}{10}$ lbs. 1,000 lbs.

If 10,000 lbs. were boiled in a clean vessel till no moisture remained $8\frac{59}{100}$ lbs. would be left, as a portion of the water is chemically combined with the saline matter.

$7\frac{82}{100}$ lbs. of the dry ingredients of this water, are resolved by analysis into

Chloride of Sodium, (common Salt,) - -	5.15
Chloride Magnesium, (bittern,) - -	.57
Chloride of Lime, (muriate of Lime,) - -	.19
Sulphate of Soda, (Glaubers Salts,) - -	.96
Carbonate of Soda, (Sal Soda,) - -	.84
Silica, (earth of flints,) - -	.08
Alumina, (pure clay,) - -	.03
—	7.82

The chemical composition of this water is such as to remove all doubt of its being affected by surface water, and denotes that its source is distant from the ocean. It contains a portion of carbonate of soda, a substance which very rarely occurs in waters. This salt is of an alkaline nature and gives to the water a degree of softness, which renders it suitable for washing clothing, and more valuable for culinary purposes generally, than rain water from the roofs of buildings.

As a drinking water, it is preferable to the well waters of the country, and very far superior to those of the city, indeed it is quite unusual to find a water, containing saline ingredients of so little injury to its qualities. Its composition indicates, that its action on metallic bodies in the way of corrosion, will be very slight, and if precautions are taken to avoid using any but the transparent water, the depositions which are produced when some waters are used in boilers, will not take place with this to any considerable extent. When 10 hhds. have been vapourized in a boiler, a suspended earthy matter, weighing, if dry, one fifth of a pound, will be obtained.

Respectfully,

(Signed,) A. A. HAYES.

Roxbury Laboratory, June 1, 1837.

DANIEL TREADWELL, Esq.,

Water Commissioner, &c.

DEAR SIR :—In answer to your inquiry respecting the water of the Artesian Well, at the depot on South Cove, I state that it never has been pure enough to use in Locomotive Engines, it is quite muddy and contains too much salt. The latter is found incrusting on the outside of the boiler, wherever a leak occurs. The effect on the engines is to cause them to foam, technically to *prime*, the water passes with the steam through the cylinders and out at the exhaust pipes in such wise that the power is completely nullified. This I attribute principally to the salt, as we find, that when the water has been allowed to settle, and becomes comparatively clear, an Engine will run well

15 or 16 miles, and then all at once, spout out the water, doubtless owing to the fact that the water in the boiler has become more highly charged with salt, in consequence of the evaporation. Many persons have supposed that this water (the supply of which is copious and drawn from a depth of 132 feet) would improve by use, but thus far, it has grown worse, being now, much thicker than at first. The principal sediment is clay.

Very respectfully,

Your ob't serv't,

J. F. CURTIS, *Superintendent.*

December 1st, 1837.

P. S. The superintendent of the machine shop states that when first pumped it is offensive to the smell.

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